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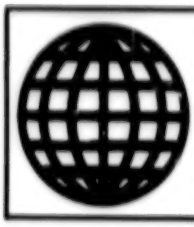

JPRS Report

Science & Technology

CHINA: Energy

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Three Gorges Dam Gets Go-Ahead

40100030A Beijing CHINA DAILY in English 4 Apr 92 p 1

[Article by staff reporter Li Hong: "Three Gorges Dam Gets Go-Ahead; Draft Laws Approved at NPC Session"]

[Text] The Seventh National People's Congress (NPC) concluded its fifth, and last, session yesterday in Beijing, endorsing the State Council's government work report, three draft laws, and also giving the go-ahead to the long-disputed Three Gorges dam project.

The 15-day meeting of China's legislative body, beginning March 20, has largely been guided by the recent statements of veteran leader Deng Xiaoping, advocating an open-minded and bolder approach in building socialism with Chinese characteristics.

The government work report, delivered by Premier Li Peng, was approved with an overwhelming majority, but after more than 150 changes were made during the deliberation by nearly 3,000 deputies.

Of the 2,633 deputies attending yesterday's closing session held in the Great Hall of the People, 1,767 voted in favour of the 57-billion yuan ($10.5 billion) Three Gorges dam project on the Yangtze River, while 177 voted against, and 664 abstained.

Also approved at the meeting were the government's 1992 draft plan for economic and social development, the 1992 State draft budget, and an election programme for deputies to the Eighth NPC, which will convene next year.

Also passed at the final session were the Trade Union Law—which ensures that China's working classes are masters of the country—the Law on the Protection of Women's Rights and Interests—which guarantees women's equality with men—and the Law on Deputies of the People's Congress at All Levels—which was designed to improve the people's congress system.

Premier Li Peng's government work report, much shorter compared with previous years and having been revised on the opinions solicited from the deputies, is "based on facts," the session said. Of the 2,936 deputies present yesterday, 2,583 voted for it.

The report calls for adhering to the Party's basic line, and never losing sight of the central task of economic development. It emphasizes stepping up reform and opening wider to the outside world, the session said.

The work report says that it is important for China to draw on the achievements of civilizations the world over, and take in both planning and market forces, two methods of running an economy.

"It is crucial for cadres at all levels to further enhance their consciousness of implementing the Party's basic line and guard mainly against 'leftist' deviations, while watching out for 'rightist' deviations," the revised report said.

The Communist Party's basic line, which focuses on economic construction, must remain unwavering for 100 years, it said.

Li's work report said that it is imperative for China to have several periods of higher economic growth and better economic performance in its modernization drive.

"If work in all fields is done better this year, there will be a more solid foundation for a faster development in the economy in the last three years of the Eighth 5-Year Plan period (1991-95)," an amendment to the report said.

On the role of the share-holding system, the revised report added that the system "will help change the methods of operation of enterprises."

The government must continue to give play to the useful and supplementary role of the individual and private sectors, the report said.

Yesterday's session demanded that the State Council and local governments at all levels make all-out efforts to carry out the tasks put forward in the government work report.

The annual NPC session voted to dam the 6,300-kilometre-long Yangtze River, the third longest in the world.

It decided to include the gigantic project in the country's 10-year (1991-2000) programme for national economic and social development, and authorize the State Council to implement it at an appropriate time, in light of China's actual conditions and its financial and material strength.

The session stressed continuous research and accurate resolving of problems.

This is the first time the Chinese Government has submitted a major project proposal to the NPC for deliberation and approval.

The dam project, proposed by the State Council, was said to be "essential for the promotion of the overall national strength, and will lay a solid foundation for national economic development in the next century."

Further Preparation on Three Gorges Dam Project Planned

40100031 Beijing CHINA DAILY in English 6 Apr 92 p 1

[Article by staff reporter Gao Anming]

[Text] Construction of the colossal Three Gorges Dam will start "some time in the 1990's", a leading official

announced on Saturday—a day after the project was endorsed by the country's top legislature by a two-thirds majority.

But Water Conservancy Minister Yang Zhenhuai ruled out the possibility of an immediate start saying time was needed "to study further some lingering questions, design the project, resettle local residents and work out financial plans."

Yang, who also heads the State Commission for Reviewing the Three Gorges Project, said: "It is difficult to tell when the project will actually start. It is up to the State Council to choose an appropriate time in the light of the nation's material and economic resources."

On Friday, the closing session of the National People's Congress approved listing the dam in the country's 10-year program for economic and social development (1991-2000) after 1,767 legislators voted for the project, 177 against and 664 abstained.

Yang told a news conference on Saturday that he was satisfied with the voting results, adding: "It was in line with democratic procedures."

"We fully understand and respect those who abstained because of doubts on the project or other reasons," Yang said. "But abstentions do not necessarily mean the delegates are against the project.

"We will provide all sectors of society with detailed material and research findings from the past decade, and we welcome, respect and will treat seriously different views at all times, even when the project has actually started."

The Minister pledged further research into unresolved issues, especially those which caused concern among NPC deputies and various social circles.

On financing, it is estimated that 44 percent of the investment will come from the project itself as it starts generating electricity in the ninth year of construction, and the revenue from the Gezhouba hydroelectric power station, said You Jiahou, head of the project's economic feasibility study group.

The government is expected to devote part of its planned capital construction fund and its budgetary spending on the project, too, but that "only makes up a small proportion," You said.

The government plans to impose a special electricity tax on areas that will benefit from the proposed dam, issue bonds and shares, and use overseas loans on favorable terms, You said.

But neither You nor Yang revealed how much China will borrow from overseas investors.

The government will start issuing bonds and shares once the State Council establishes a steering group to coordinate and supervise the project, Yang Zhenhuai said.

The government has already earmarked money for further studies and trial resettlement programs for this year but he gave no details.

"China has the ability to build the dam," Yang said, "but in line with our policy of reform and opening to the outside world, we want the world's most advanced technology and equipment for the dam."

Potential Energy Crisis in China

926B0068a Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese 25 Feb 92 pp 4-5

[Article by Zhou Dadi [0719 1129 0966] and Chu Ming [0443 2494], State Planning Commission and Energy Research Institute, CAS: "Potential Energy Crisis in China"; first installment]

[Text] Population, agriculture, energy, and the environment are problems that almost all developing countries must face in the course of their development. China's government has taken many concrete steps in an effort to solve the problem of energy supply and demand, but for about the last decade, economic development has constantly been constrained by energy shortages, whose effect has been gradually worsening. An even greater cause of concern is that several of the basic factors that have given rise to energy shortages have persisted, and that in some respects we are worse off then we were 10 years ago. Although the economic slump of the last 2 years has produced some temporary alleviation of the energy supply and demand problem, when a significant upturn of industrial output occurs, the severe shortfall that we experienced before last year will return with increasing severity.

I. China's Energy Shortage Is Extremely Serious

China's energy shortage is a long-term, persistent, cyclic problem.

Consider, for example, the shortage of electric power. In the 40 years from 1949 to 1989, there were shortages in 25 years, including short-term shortages in the Beijing-Tianjin-Tangshan area in 1953, in 23 areas of the country in 1956, and throughout the country in 1958-60. But from 1970 until the present, there has been a long-term, nationwide electric power shortage. The geographic extent and magnitude of the shortfall have gradually increased; during the first 4 years of the Seventh 5-Year Plan in particular, cutoffs of electric power became increasingly frequent and covered larger and larger areas, not only causing great economic loss, but also directly affecting the people's livelihood and contributing to increasing instability.

Experts state that China's current electric power generating capacity is more than 17 GW [gigawatts], but the shortfall in electric energy output exceeds 70 TWh [terawatt-hours]. Some experts estimate that the actual shortfall in electric power generating capacity is nearly 70 GW and that the shortfall in electric energy output

exceeds 190 TWh. In other words, the shortfalls in both power generating capacity and electrical energy output exceed 15 percent. A shortfall of this magnitude cannot be eliminated quickly.

The main direct cause of the electric power shortfall is insufficient generating capacity; an inadequate coal supply is also a major factor. During the Sixth and Seventh 5-year plans, there were two nationwide coal shortages. The rapid development of the east coast in the period through 1985, in which the provincial and municipal heads took the lead and all manner of attempts were made to step up coal output, is still fresh in people's minds. Local coal mines, and especially rural and township coal mines, were developed on a large scale, and for a time they alleviated the coal shortage. But this improvement was short-lived: a ubiquitous coal shortage that began in 1988 lasted more than 2 years. In some cases, piles of gangue that had been accumulating for many years at major coal mines were actually sold as coal to desperate users. Experts conclude that the annual increase in coal output lagged behind the increase in demand by more than 10 million tons, and that the cumulative shortfall over the Seventh 5-Year Plan was 70 million tons.

Petroleum and petroleum products have long been in short supply and subject to use restrictions. Since the Sixth 5-Year Plan, the government has maintained a comprehensive policy of decreasing the combustion of oil. But starting in 1986, shortages of electric power and a variety of rational and essential requirements for the combustion of petroleum products have created a steadily increasing pressure, with the result that the burning of oil has again been on the increase. In terms of state policy, the primary use of petroleum is for mobile machinery (motor vehicles, boats, aircraft, tractors and the like) and as an essential chemical feedstock. From 1980 to 1988, China's domestic gasoline supply increased by 79.2 percent and its kerosene supply by 55.3 percent, but civilian motor vehicle ownership grew by 133.2 percent, and boats in the civilian sector by 142.7 percent; there were also significant increases in other types of internal-combustion machinery, and the supply of all petroleum products fell short of demand. The result is that, at present, while there has been a temporary alleviation of the coal and electric power shortages, the supply of petroleum products is still rather tight.

Natural gas, which is now the third-largest and the fastest-growing energy resource worldwide, has been all but ignored as a component of the energy balance in China. In the last 10 years, natural gas output has dipped and has finally returned to the 1980 level. The question of whether it should be used in the civilian sector or as a chemical feedstock has been debated for many years by energy experts. In either use, its social benefits are highly significant. The crux of the problem is that China's current natural gas output is only a minuscule fraction of the potential demand.

II. Future Energy Resource Prospects Are Grim

Current mid- and long-term energy forecasts are that the energy supply will remain extremely tight for a rather long period.

A. The pace of economic development will remain high for the next 10 years. In order to meet the development objectives for the year 2000, our economic growth rate must be significantly above the world average. Owing to steady population growth and the fact that the current size of the rural population still greatly exceeds agricultural manpower needs, there is tremendous pressure to move to industry and to the third sector [i.e., the service sector]. Furthermore, China's basic facilities are still extremely backward, economic growth by the extensive model of expanded reproduction will still retain its primacy, and investment in fixed assets will remain the chief factor driving economic growth for a long time to come. Many experts in China and abroad estimate that if China's rate of economic growth recovers, the annual growth rate of the economy over the next 10 years can still exceed 7 percent.

B. China's current level of energy consumption is still extremely low, lagging far behind not only the industrially developed countries, but also behind the world average. Based on the 1988 energy consumption rate and a population of 1.09 billion persons, China's per capita consumption of primary energy resources is 852,000 grams of standard coal, only 36 percent of the world average figure; per capita coal consumption is 647,000 grams of standard coal, or 95 percent of the world average; per capita petroleum consumption is 144,800 grams of standard coal, or 16.8 percent of the world average; and per capita consumption of natural gas is 17,700 grams of standard coal, or 3.9 percent of the world average. The per capita consumption of electric power is 500 kWh, or 24.2 percent of the world average.

C. There have been many energy requirement forecasts for China's provinces, municipalities and regions, and all of these figures far exceed anything that could be met by the country's energy resource development targets. National energy demand predictions generally make thorough allowance for energy supply conditions and place great hope in the potential offered by energy conservation; although their results differ, the great majority predict that the demand for primary energy resources in the year 2000 will be more than 1.5 billion tons of standard coal, considerably above the figures envisioned by the current energy development program.

D. The energy industry is hard-pressed everywhere and lacks a driving mechanism capable of accelerating its development. The energy industry's financial condition is universally worse than it was 10 years ago. The coal industry is losing money across the board, up to a billion yuan per year. Increases in coal production have relied chiefly on the rapid development of rural and township mines, but their staying power has consistently been disappointing. The petroleum industry entered the ranks

of across-the-board money losers in 1988. Current investments are sufficient only to maintain current output levels. Many experts believe that under current conditions the petroleum and natural gas output projections for the year 2000 are unattainable. Although the electric power industry has been developing rather rapidly in the past 3 years, its profitability rate fell from 13 percent in 1980 to 5.8 percent in 1988. Hydropower development has been the chief victim of the power industry's inability to finance its own development. To achieve the objective of having hydropower provide 20 percent of total electric power output by the year 2000, it will be necessary to commission more than 3.5 million kilowatts of hydroelectric power stations every year for the next decade; otherwise, the shortfall of primary energy resources will increase further. But at present, less than 2 million kWh of hydropower capacity is being commissioned each year.

Development of Oil, Gas Prospecting in China

926B0068B Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese 25 Feb 92 pp 6-8, 5

[Article by Chen Juan [7116 6855/0656/5131], Institute of Petroleum Prospecting and Development: "Oil and Gas Prospecting and Development in China"]

[Text] The petroleum industry is a major pillar of China's economy, and oil and gas are major strategic materials which not only directly affect the development of the energy, defense, chemical engineering and transport sectors, but also agriculture and other industries; they are products with great processing value and with great upvaluation potential as well as major resources by which China can create foreign exchange.

I. Oil and Gas Prospecting Is Achieving Splendid Results and Has Extensive Prospects

Resource evaluation is been performed on 143 Paleozoic, Mesozoic and Cenozoic basins on dry land and on the continental shelf (including 3 marine-facies sedimentary regions), with a total area of 4.5 million square kilometers. Since the state was founded, spectacular progress has been made in geological prospecting for oil and gas, including the discovery of 441 commercial oil and gas fields in 19 basins, and explored geological reserves of oil and gas are much greater than they were before liberation. The scope of oil and gas prospecting is broad, but its thoroughness is variable and generally low. In East China, circumstances are favorable for the steady discovery of large oil and gas fields in shallow seas and other offshore regions, and there is a possibility of finding complex or deeply hidden oil and gas or pools in older basins and in new medium-size and small basins, e.g., pools with complex pay strata, complex lithology, or complex small-block structure, as well as low-permeability, low-productivity, or superdeep medium and small-size oil and gas pools or pools of thick oil. There is some prospect for finding large and medium-size oil and gas fields in the west and in extensive sea basins (e.g., at the mouth of the Pearl River, in the Yinggehai and Beibuwan areas, southeast of Qionghai, in the Donghai and southern Yellow Sea areas, in the Taixi basin and the like). The surface conditions in the areas are difficult or even dangerous, climatic conditions are variable and complex, and the locations are socially and economically underdeveloped border regions; the unique problems that they present spring from the above factors and from geological complexities, e.g., complex structural conditions, unusual trap types, a variety of pool types, complex pay stratum structure, a diversity of pay stratum types, pay strata at great depths. But these very large or large oil-containing basins are sure to contain medium and large-scale oil and gas fields of relatively simple structure that are ready for development. During the Seventh 5-Year Plan, excellent oil and gas prospects were found in the Tarim Basin, including the Lunnan area (where commercial pools have already been found), the Taizhong region, and the Yingmaili region, but under conditions that are relatively complex; major breakthroughs have been made in the Turpan Basin, and the Shanshan oil field and the Qiuling and Yilahu regions have significant reserves; important breakthroughs have also been made in the eastern Dzungarian basin, including the Huoshaoshan and Beisantai oilfields; offshore, some medium and large-scale oil and gas accumulations have been found at the mouth of the Pearl River and in the Yinggehai Basin. To make comprehensive breakthroughs in the above basins and get at the main oil and gas pools will require time and unremitting hard work, as well as personnel, advanced scientific and technology, modern and well-rounded suites of equipment and an appropriate management system; but ultimately, it will need to be supported by extremely large investments.

II. Oil and Gas Production Is Expanding Rapidly, But Under Trying Circumstances

In the 42 years since the state was founded, China has made great strides in oilfield development and production. More than 20 oil and gas production bases have been established, and as of the end of 1990, China had a crude oil production capacity of 141 million tons and a natural gas production capacity of 15 billion cubic meters. We entered the ranks of the world's major oil producers in the early 1980's. China's oil and gas extraction technology is advancing rapidly, and oilfield development has reached a rather high level. The rate of oil extraction has consistently been rather high, so that the natural annual rate of decline in oilfield output is 0.86-0.84 and the overall annual rate of decline is 0.943-0.923. Calculating from the overall rate of decline, the cumulative decline in production over 5 years is 43.41 million tons, while newly added oil producing capacity over the same period is 78.08 million tons, giving a cumulative net increase in production capacity of 34.67 million tons and a real cumulative increase in oil output of 13.38 million tons, equivalent to an annual average net increase in output of 2.68 million tons. In 1988 and 1990, the net annual increase in output was only 620,000

tons. The Eighth 5-Year Plan requires that the output of crude oil be increased from 138 million tons in 1990 to about 145 million tons in 1995 and that an effort be made to achieve a rather large increase in production by the year 2000; but in view of the real net annual increase in output, this is a rather large and difficult gap. Thus, maintaining a stable output of crude oil and increasing production will be a rigorous task. The recoverable reserves newly added during the Seventh 5-Year Plan were far below the amount of oil extracted during the same period; the reserves-to-output ratio in 1990 was 2.87 percent lower than that for 1985, which indicates what an arduous task of increasing recoverable oil reserves lies ahead.

III. Increase Investment in Prospecting, Increase Reserves

During the Seventh 5-Year Plan, inadequate funding greatly constrained prospecting activities and technological development, so that during this period there was actually a relative contraction of prospecting activity that directly hindered the effort to increase explored oil and gas reserves. During the Seventh 5-Year Plan the nominal investment in prospecting increased by 78 percent over that of the Sixth 5-Year Plan, but if we correct for an increase in material costs and operating costs, increased difficulty of prospecting and the like, the real increase in investment was very small; as a result, the total amount of prospecting work performed was nearly at the same level as during the Sixth 5-Year Plan, exploratory well footage was only 51 percent of the target, and the total amount of explored oil and gas reserves added to the books was 74.2 percent of the target; the investment required for the addition of 100 million tons of explored reserves was twice that required in the Sixth 5-Year Plan, and the actual investment amount fell about 12-16 billion yuan short of what would have been required for attainment of the Seventh 5-Year Plan targets.

It is evident from the above figures that although in overall terms China's oil and gas reserves are rather abundant and a relatively small fraction of them has been explored, our per capita oil and gas reserves are actually rather small. As a consequence, we must intensify efforts to develop and utilize our limited, precious, scarce oil and gas reserves, and in the course of economic development we must step up our attempts to find their best strategic utilization.

Ultimately, the development of the oil and gas industry depends on geological prospecting. If no progress is made in this activity, there will be no increase in the oil and gas reserves on the books, so that it will become impossible to correct the current situation, in which the ratio of reserves to extraction is declining, maintaining steady output is difficult, and increasing output is problematic. Thus, stepping up all aspects of prospecting and increasing the explored geological reserves of oil and gas still constitutes the central task on the petroleum front.

Progress in oil and gas prospecting requires huge investments; otherwise, it will be difficult to reverse the current relative contraction of prospecting work. Consequently, facilitating funding channels for prospecting, universally instituting the compensated use of resources, and fully including exploration costs in crude oil production costs are the correct ways of moving prospecting work into a beneficial cycle.

IV. Some Problems in the Technical and Economic Evaluation of Oil and Gas Resources and Some Suggestions for the Future

In order to further strengthen the management of oil and gas resources and to improve technical and economic analysis, the National Mineral Resources Commission decided that in 1988 it would begin nationwide trial implementation of temporary regulations for the technical and economic evaluation of oil and gas reserves. Technical and economic evaluations of the explored reserves of 35 oil and gas fields over the past 2 years have not produced encouraging results. Under the requirement for comprehensive economic evaluation, an economic evaluation of the prospective economic benefits from future industry development indicated that even if compensated utilization of reserves were instituted and if new selling prices were calculated at parity, the internal earnings rate would be essentially negative, and that the unit production cost of commodity oil or gas evaluated by the total-cost method would be significantly higher than the current parity value. This result indicates, at the very least, that the exploration, development and capital-construction components of industry consumption and expenses have not been fully included in production costs, and that in fact less than half the value of these components has been included: thus, on the basis of the current compensated resource utilization fees, it would be possible to raise only about 40 percent of the funds needed annually for exploration. These results indicated that unless effective arrangements for funding prospecting were made, unless prospecting efforts were strengthened and the amount of prospecting work was increased, and unless investments in prospecting were guaranteed, it would become difficult to maintain a steady growth of oil and gas reserves and to increase output. Another problem that emerged from the economic evaluation of reserves was that even if the selling price were calculated in terms of the current high price, the economic benefit from future industry development of newly added reserves would have about ⅓ the profitability rate of newly added reserves, falling short of the standard industry profitability rates prescribed for the economic evaluation, and the technical and economic evaluation of newly added oil reserves from the main area of effort in the west and from offshore areas would essentially have to be based on "shadow prices" or international prices. Thus, two problems are evident. The first is that the petroleum industry must use a comprehensive economic accounting procedure that takes account of the entire process, from prospecting to development and production (where "comprehensive" implies industry economic accounting

that encompasses the entire process and all personnel). Oil prospecting accounts for about one-third of total petroleum industry expenditure and is the spearhead of the entire petroleum production process; thus, prospecting costs must be incorporated into crude oil production costs by the full-cost method (i.e., considering enterprise product output and product sales, the so-called "sum of consumption and expenditure"). This is the only way to meet the requirements for comprehensive economic accounting and to make an objective, realistic analysis of the economic conditions and environment that China's petroleum products encounter and of the position that their macroscopic and microscopic benefits occupy in the context of major cycles on foreign markets, so that it becomes possible to consider specifically targeted, scientifically and technically based, management-based and economically based measures and to find an effective policy for decreasing production costs, improving quality, and increasing economic effectiveness. Second, we must rationalize the sales prices of oil and gas products in timely fashion; once these prices are rationalized, the petroleum industry will be able to function as an important pillar of economic development and increased state accumulation while continuing its own self-funded accumulation and development. The petroleum industry's implementation of comprehensive economic accounting and the rationalization of oil and gas commodity prices must be carried out thoroughly and simultaneously: otherwise, the funding channels for prospecting, development and capital construction will remain closed or will be incompletely opened, and as a result, the petroleum industry's development will be unlikely to enter a beneficial cycle. We therefore suggest that the first step should be the institution of new prices for new oil and gas; that where a basic output level has been contracted for, output above this level should still be marketable at the current high price; and that in contracting for a base output level, 25 percent of output should be adjusted to the current high price each year. The purpose of these proposed changes is to assure that the oil and gas commodity selling prices are rationalized during the Eighth 5-Year Plan (the new prices can be provisionally set in terms of the current high price). This policy readjustment should bring significant benefits in four areas.

A. Alleviation of the burden on state finances and implementation of self-financed accumulation and development. In 1990, petroleum exploration funds were more than double the level of the Sixth 5-Year Plan. As prospecting becomes more difficult and the amount of work that is needed increases, prospecting expenses will rise from year to year: thus, to increase total explored reserves of oil and gas by 45 to 50 percent by the year 2000 will require an increase of about 10 billion yuan in funds for prospecting. If prospecting expenses are incorporated into the production cost of crude oil, if selling prices are rationalized so that funds spent on prospecting are recovered and are used earmarked especially for prospecting, this will increase the oil and gas industry's backlog of reserves, help maintain a rational reserves-to-extraction ratio, and increase the petroleum industry's ability to maintain a steady rate of growth.

B. Rational utilization of oil and gas resources and reserves. China has long followed the policy of "no price for minerals, low prices for starting materials, and high prices for manufactured goods," the result of which has been the uncompensated use of mineral resources. Oil and gas are no exception, and since in addition the ratio of the prices of crude oil and refined oil is low, this promotes high energy consumption, high production costs, low profitability rates, the operation of small refineries with obsolete processes and technologies, and ill-considered development of local refineries. In addition, oil for combustion makes up a large fraction of the consumption structure: in 1990 the amount of oil burned was equivalent to the output of several medium-sized oil fields. This situation does not promote the rational utilization of our precious oil and gas reserves: it actually stimulates increased consumption or even waste of oil and gas resources and brings about ecological damage and environmental pollution. If the petroleum industry implements comprehensive economic accounting and simultaneously rationalizes selling prices, this will promote technological progress in refineries, will increase profitability rates, will result in a wider range of product varieties and improved quality, and will increase the comprehensive utilization rate, which will foster a greater desire to be competitive on foreign markets, produce an overall restraint on the economy's demand for petroleum, and bring about a changeover to an energy-conserving economy.

C. Thorough mobilization and utilization of existing explored reserves. If the petroleum industry implements comprehensive economic accounting and concurrently rationalizes the selling prices of oil and gas products, the extraction industry will have an incentive to carefully design and organize the bringing of oilfields, tracts and pay strata into production, to make integrated adjustments of production activity in older regions, to improve the dynamic situation in zones under development, to overcome an excessive concern with short-term benefits, to organize rational development, and to make thorough use of existing reserves in order to increase the ultimate resource recovery rate of oil and gas fields. In addition, when there is relatively ample funding for prospecting, development and capital construction, the extraction industry will respond by bringing hard-to-develop explored reserves that involve high production costs and long mobilization times into production in stepwise fashion, so that they produce the proper resource benefits and economic and social benefits. Adequate funding of prospecting will also make the extractive industry take the initiative in correcting the current low level of companion natural gas production capabilities and the low natural gas commodity conversion rate.

D. Implementation of a focused investment policy. The suggested changes will promote the concentration of financial resources in order to organize key breakthrough efforts in prospecting activities and in major scientific

and technological areas with the objective of achieving advances. If the share of natural gas both in the overall energy output structure and in the energy consumption structure were increased by 3 percent, the resource benefits, environmental benefits and economic benefits would be considerable. In addition, concentration of financial resources, self-reliant and self-supporting development of technology for offshore oil and gas exploration and extraction, and an accelerated pace of offshore oil and gas development would bring about concurrent, coordinated increases in both explored reserves and the output of oil and gas, thus yielding great resource benefits and economic benefits.

Qinghua University Nuclear Energy Research Institute Reorganizes

926B0072B Beijing GUANGMING RIBAO in Chinese 16 Feb 92 p 2

[Article by Reporter Ma Xuquan [7456 2700 3123]: "Qinghua University Nuclear Energy Research Institute Blazes New Management Trail"]

[Text] The Nuclear Energy Design and Research Institute of Qinghua University has scored remarkable success in reforming its internal management. The number of working personnel in the institute has been cut by more than half; the percentage of intellectuals increased from the former approximately one-half to two-thirds of the total number of personnel; and the per capita investment in scientific research increased from 100 to more than 40,000 yuan per year.

In 1984, the Nuclear Energy Institute (the predecessor of the Nuclear Energy Research Institute) put into effect a responsibility system for the head of the institute and for the directors of all laboratories, as well as an appointment system for all professors, staff members and workers. In 1988, the research institute put into effect a matrix style work management system for the two research laboratories for its reactor project, dividing them into five laboratories by academic specialty. This greatly spurred progress in building a 5 megawatt low heat nuclear reactor for supplying heat. At the same time, the institute instituted a system whereby personnel within the institute could move from one position to another. This enabled an optimization of personnel groupings. The institute also divided working personnel into three categories on the basis of their work attitude, abilities, and achievements, namely regular appointments, trial appointments, and candidate appointments, thereby spurring lagging comrades to change their ways. In the course of management reform, the nuclear research institute emphasized the key evaluation link, using different evaluation methods for professors, workers, administrators, and researchers, and for staff and logistical personnel.

Management reform at Qinghua University's Nuclear Design and Research Institute has effectively aroused the initiative of all professors, staff members, and workers. It has spurred along academic leaders, and has steadily improved the skills of key cadres in all positions. Young professors have matured rapidly, and some production experts have also come to the fore among workers.

Experts Urge Priority Study of Overall Electric Power Policy

926B0072A Beijing GUANGMING RIBAO in Chinese 16 Feb 92 p 2

[Article by Correspondent Zhai Huisheng [5049 1920 3932]: "More Than 100 Experts Including Sun Jiaping [1327 0857 1627] Propose Priority Study of Overall Electric Power Policy"]

[Text] By the year 2000, China will have 240 million kilowatts of installed electric power capacity, enough to support only a 5 percent increase in GNP, but not enough for 6 percent or more growth. Therefore, a far-reaching and pervasive study centering around electric power, should be made of overall policy making for energy production in order to provide sufficient scientific data to assure the coordinated development of the electric power industry and the national economy. This proposal was jointly made by high ranking engineer Sun Jiaping and more than 100 experts in the Water Conservancy and Electric Power Information Office.

The purview of a study of overall policy making in the electric power industry includes rational use of energy, understanding the correlation to the ecological environment of the development of energy and electric power, obtaining rights to environmental space, and how to make the energy and electric power management system meet needs for development of the national economy, etc. The experts proposed that during the Eighth 5-Year Plan period, the goal in studying overall electric power policy making should not be limited to the year 2000, but should look beyond. First, while studying the development of thermal power, ways and means of developing water power to the full, and active development of nuclear power should also be studied, with special emphasis given to the problem of greater environmental protection in the generation of thermal power. Second, emphasis should be placed on the conservation of energy and greater investment of funds in conservation, efforts made to develop and spread new energy-saving techniques and new technology, and to encourage the development of energy saving and multiple energy source types of household electric products. Third, in order to provide customers with ample, reliable, equitable, and cheap electric power, study should be devoted to the industry's internal operating mechanism and management methods, including how to continue and how to manage well the pooling of funds to run power plants, how to improve the electricity pricing system and straighten out electricity prices, and how to raise funds for the renovation and technological transformation of electric power supply equipment, thereby expanding electric power enterprises self-management, operating initiative, and self-development capabilities, and introducing electronic computer quantitative simulating techniques.

Guizhou To Add Over 5 Million kW in Next 10 Years

926B0058D Guiyang GUIZHOU RIBAO in Chinese 15 Dec 91 p 1

[Article by Zhang Junyan [1728 6511 3643]]

[Text] A delegation from Guizhou Province recently visited departments, commissions, offices, banks, and companies in Beijing. Together with leaders from these departments, they discussed and planned electric power development in the Eighth and Ninth 5-Year Plans and the construction that is to begin next year.

The Ministry of Energy Minister Huang Yichang [7806 3015 6134] maintains that, with the water and coal mine resources, Guizhou Province should not only provide for itself, but also for neighboring provinces. Guizhou should become a real energy base. The recent meeting between the Guizhou provincial government and relevant departments of the state was conducted along this line.

After repeated discussion, it was decided that Guizhou will construct, continue the construction, or remodel the following electric power projects in the next decade. Thermal electric power plants include the first phase of Aushun plant, the Feitian power plant, the Guiyang power plant, the Duyun power plant, the Kaili power plant, and the Panxian power plant. The total capacity will be 1.60 million kW. Funding for the first phase new construction of the Aushun power plant has been arranged. The down-sizing remodeling of the Guiyang power plant is scheduled for construction preparation in 1992. Based on the policy of simultaneous development for hydroelectric and thermal electric power, Guizhou is also scheduled to begin construction of the Hongjiadu and Goupitan power plants. These two large hydroelectric power plants will have a combined capacity of 2.45 million kW. The Hongjiadu project is expected to enter the construction preparation phase in 1992 or 1993, after the investment peak period for the Dongfeng power plant. The Goupitan project is slated for the Ninth 5-Year Plan period. In terms of power grid construction, it was decided that a 500 kV transmission circuit will be built from the Longtan station on Hongshui He toward central Guizhou. This will be the second channel for Guizhou to feed power to southern China, after the 500 kV transmission line for electric power development in Guizhou in the next 10 years has been clearly mapped out. Today, the capacity of the Guizhou power grid is 2.025 million kW, with an additional 1.2 million kW under construction. After the next 10 years, the capacity will increase many fold.

Outlook for Hydropower Projects in 1992

926B0069A Beijing SHUILI FADIAN [WATER POWER] in Chinese 12 Feb 92 pp 3-4

[Article by Zhu Erming [2612 1422 2494], director, Water Conservancy and Hydropower Planning and Design Academy: "Outlook for Early Stage Water Conservancy and Hydropower Work in 1992"]

[Excerpts] [Passage omitted] In the hydropower realm, in 1991 large, medium, and small hydropower stations with an installed capacity of 1.22 million kilowatts came on stream, and medium and small rural hydropower power stations with an installed capacity of 1.05 million kW were added. In addition, the state approved construction of a number of large and medium size hydropower stations including the Ertan, Tianshengqiao-1, Daxia, and Taipingyi stations. These stations are to produce more than 5 million kW of electric power. As of the end of 1991, large and medium size hydropower stations under construction nationwide will eventually produce 19.93 million kW; 10 of them are stations of 1 million kW or more. [passage omitted]

The main tasks in 1992 are as follows:

[Passage omitted] In the hydropower realm, the focus during 1992 will be on strict attention to preliminary design work for projects on which work is to begin during the Eighth 5-Year Plan. For projects for which preliminary designs have been completed, supplementary design optimization work will continue on the principle of good economic sense and improved returns. For projects on which work is to begin during the Ninth 5-Year Plan, feasibility studies are to be tendered as soon as possible. Early stage work on large and medium size hydropower projects for which local governments and departments are to raise funds should be scheduled as a priority matter. Of the 46 water conservancy and hydropower survey and design projects scheduled for 1992, 15 are being planned and plans are complete for five. Feasibility studies have been done on 15 totaling 29.95 million kW, and plans have been completed on four totaling 2.78 million kW. Preliminary design work has been done on 17 totaling 31.19 million kW, and planning has been completed on eight totaling 3.53 million kW. The main projects being planned are: the Heishanxia river section plan, the Jinping Dahe bend plan, the Jinsha Jiang (Shigu-Dukou) plan, the flow plan for the Suichuan Jiang in Jiangxi, review of the Ou Jiang plan for Zhejiang, review of the plan for the Ou He Basin in Hunan, and the Hainan hydropower plan. The main projects for which feasibility studies have been done are the Xiangjiaba and the Xiluodu on the Jinsha Jiang, the Tongzilin hydropower station on the Yaxi Jiang, the first phase of the second stage of Jinping, the Nuozhadu hydropower station on the Lancang Jiang, the Sanban Creek hydropower station in Guizhou, the Anfengqiao hydropower station in Fujian, the Wulong Shan storage-power station in Zhejiang, the Baozishi hydropower station in Jiangxi, and the Xilongchi pumped-storage station in Shanxi. The main preliminarily designed projects are as follows: The key water conservancy project in the Three Gorges of the Chang Jiang, the Pubugou and the Yaoheba hydropower stations in Sichuan, the Xiaowan and the Dachaoshan hydropower stations in Yunnan, the Silin and Goupitan hydropower stations in Guizhou, and the second phase of the second stage of the Tianshengqiao in Guizhou; the Laxiwa, Gongboxia, and Jishixia hydropower stations in Qinghai, the Xunyang and the second stage of the Shichuan hydropower stations in Shaanxi, the Lingjintan hydropower station in Hunan, the Gudongkou hydropower station in Hubei, and the second phase of the Guangzhou pumped-storage power station. The main projects for which design tenders have been invited are: the Longtan hydropower station on the Hongshui He, the Tianhuangping pumped-storage power station in Zhejiang, the Lianhua Shui power station in Heilongjiang, and the Xiaolangde and Wanjiazhai key water conservancy projects on the Huang He.

While doing early stage work, all institutes must further study the technical design, the design for invited tenders, construction drawing designs, and on-site design work for projects under construction. Electric power generation nationwide is to reach 710 billion kWh in 1992; and large and medium size electric power generating units generating 10 million kW are to go into production of which large and medium power generating units will generate 2.07 million kW. Medium and small hydropower stations going into production will also have an installed capacity of more than 1 million kW. Thus, a good job on design work for projects under construction is also a very important task. Design units responsible for project monitoring must diligently monitor projects for safety and problem-free construction.

The feasibility study for the Three Gorges project in the Chang Jiang that has attracted world attention has been examined and approved by the examination committee. The State Council is about to examine the study and prepare a report for the CPC Central Committee and the NPC requesting that the NPC discuss construction. The Standing Committee has to devote attention to preliminary design work for the Three Gorges project so as to be fully prepared for its early construction. [passage omitted]

Xinjiang Accelerates Medium, Small-Scale Hydropower Construction

926B0075A Urumqi XINJIANG RIBAO in Chinese 19 Feb 92 p 1

[Article by Correspondent Yu Qiangfu [2456 1730 1381]: "Xinjiang Accelerates Construction of Medium and Small Hydropower Construction. Reforms Investment Channels for an Increase in Sources of Funds"]

[Text] Urumqi Dispatch: Xinjiang has reformed investment channels for raising money for medium and small hydropower construction, thereby increasing sources of

funds and accelerating construction making a special contribution to vigorous development of the economy at the county level.

Xinjiang is a vast region in which oases are scattered here and there among the "three mountains and two basins" making large power grid coverage difficult. Consequently, every jurisdiction in the region uses the extremely abundant and fairly evenly spread water power resources for the vigorous development of medium and small-scale hydropower, gradually building electric power facilities in which medium and small hydropower is paramount and thermal power is supplementary.

During the Seventh 5-Year Plan, authorities in the region used summarization of the lessons of previous experience in reforming investment channels. They changed from gratis appropriation of funds to discounted loans, and from mostly state investment to mostly self-reliance, raising capital through multiple channels. Thus, they increased sources of funds, improved results from the use of funds, and expanded the scale of construction. At the same time, every jurisdiction's sense of responsibility about managing and using hydropower well was increased. Authorities concerned in the region also made the building of medium and small-scale hydropower an effective means for assisting peasants and herdsmen escape poverty to become prosperous, and for vigorous development of the county-level economy. Investment was tilted in favor of the three prefectures and autonomous prefectures in the southern part of the Xinjiang. Between 1986 and 1990, half of all the installed capacity of the entire autonomous region was installed in these three prefectures and autonomous prefectures.

Statistics show that during the Seventh 5-Year Plan, the region added 137,000 kW of medium and small-scale hydropower installed capacity, up 73.4 percent from the Sixth 5-Year Plan. Installed medium and small-scale hydropower capacity totals 450,000 kW, 43.8 percent more than in the Sixth 5-Year Plan. In 1990, medium and small-scale hydropower generated 1.42 billion kWh of electricity, 1.12 billion kWh of it coming from small hydropower. Eighty percent of counties (or cities), 70 percent of townships, 77 percent of villages, and 60 percent of peasants and herdsmen in the region use hydropower.

Dashankou To Generate Power in 1992

926B0058A Urumqi XINJIANG RIBAO in Chinese 24 Dec 91 p 1

[Article by Wang Xuelin [3769 1331 2651] reporting from Korla]

[Text] 17:45 on 12 December marked the successful filling of the lower gate of the Dashankou power station. The No. 1 generator will produce power for the grid within a year.

Dashankou power station is a priority project in the Seventh 5-Year Plan and is the largest hydroelectric station in the Xinjiang Autonomous Region. It is also the only microcomputer-controlled hydroelectric station in Xinjiang. It has a total capacity of 80,000 kilowatts and an annual output of 310 million kWh. The construction of the station, begun in 1985, has been very difficult in the last 6 years. The main dam, hydroelectric opening, main and auxiliary plant building, and the switching station have basically been completed. After the station is built, the severe power shortage in the Bayingolin Mongol Autonomous Prefecture will be greatly alleviated, and the station will also provide ample power for large-scale oil exploration activity in the Tarim Basin.

The reservoir capacity of the Dashankou station is 28.8 million cubic meters, the modulation reservoir has a capacity of 45.5 million cubic meters, the normal water level is 1,406 meters, and the design waterhead is 51 meters. The reservoir has been filled for about 1 week and the No. 1 turbine generator is ready for a test run.

Puding Update

926B0058B Guiyang GUIZHOU RIBAO, 13 Dec 91 p 1

[Article by Jiang Xingqian [5592 5281 7816]

[Text] The 75-meter-high dam of Puding hydroelectric power station, a key science and technology project of the Eighth 5-Year Plan, will be an arch gravity dam built of rolled concrete. The pouring of concrete officially began on 23 November. The dam uses an integrated thin layer pouring method. The new rolling technology continuously builds up the height. This 75,000 kW power station was built by the Wujiang branch of the 8th hydroelectric power bureau. The first generator will begin producing electricity in 1992.

Jilin Adds Record Amount of Thermal Power in 1991

926B0058C Changchun JILIN RIBAO in Chinese 12 Jan 92 p 1

[Article by He Rufei [0149 1172 7378] and Xue Li [6043 7787]]

[Text] In 1991, Jilin built a 500,000 kW thermal power plant and added a 200,000 kW generator into the power grid. This set a record for the amount of thermal power added in 1 year. It was also a year with the most electric power development under local funding.

From 1985 to 1991, Jilin has raised 1.1 billion yuan for developing electric power and jointly funded with the state the construction of 1.5 million kW of thermal power. A large-scale power plant, the Xuangliao power plant, is under construction. This plant has a total capacity of 2.4 million kW and is jointly funded by Jilin and the state, with Jilin responsible for 60 percent of the investment.

In order to speed up the pace for electric power development, Jilin also raises local money for power construction. One example is the 200,000 kW generator of the Zejiang power plant. This generator passed the 72-hour test run on 30 December 1991 and joined the grid.

While speeding up the construction of thermal electric power, Jilin is also working on power transmission and transforming facilities. In the last 6 years, Jilin has built 16 transmission lines of 220 kV or higher. The total length is 1,281 kilometers. Newly built are 17 substations of 220 kV level, and 2.34 million kVA have been added to the transforming capacity.

Infrastructure for Dalad Plant Project in Place

926B0074A Hohhot NEIMENGGU RIBAO in Chinese 31 Jan 92 p 1

[Article by Wang Zepu [3769 3419 2528]: "Preparatory Work Completed for Construction To Begin on Dalad Power Plant Project"]

[Text] Dispatch from Dongsheng. Thanks to the efforts of units and agencies concerned, and the urgent earlier work of the power plant's staff members and workers, preparations are now complete for construction to begin on the Dalad Electric Power Plant project in Inner Mongolia. Main facilities fully meet requirements for beginning work.

The Dalad Power Plant scheme has a capacity of 5 million kilowatts, 1.32 million kW in the first phase, with plans calling for the follow-on construction of four 330,000 kW power generation units. Two of the units are to go into operation during the Eighth 5-Year Plan. The Dalad Power Plant preparatory team was formally founded in December 1990, and in August 1991, the Dalad Power Plant was formally inaugurated. The preparatory team and the staff members and workers of the power plant carried forward a spirit of arduous struggle, working on the site as they planned its construction. The Inner Mongolian Management Bureau and the Dalad Power Plant conscientiously put into effect new regulations and controls from the Ministry of Energy Resources and the autonomous region for the new plant, generating a stream of guidance. They accelerated the pace of early stage work with a view to beginning construction in 1992 and putting one power generation unit into operation in 1992 and another in 1994. By the end of 1991, they had requisitioned the land, razed or removed structures from it, and put all of the infrastructure in place, and they began construction of some offices and living accommodations as well. They built five roads totaling more than 3,300 meters in length, sank seven wells producing 350 tons of water an hour, built two 300 cubic meter reservoirs, erected six power lines, leveled 12,800 cubic meters of land at the construction sight, and hauled away 24,000 cubic meters of earth to set the stage for the formal beginning of work on the project

Wujing Thermal Power Plant's First Unit Goes Into Operation

926B0074B Shanghai JIEFANG RIBAO in Chinese 25 Feb 92 p 1

[Article by Trainee Liu Liang [0491 0081] and Correspondent Zhang Zhiyuan [1728 5268 6678]: "China's First Critical Large Model Thermal Power Equipment, the Wujing Project's 300,000 Kilowatt Generating Unit, Begins To Generate Electricity. Shanghai Area-Manufactured Equipment Accounts for 77 Percent of Value of All Equipment Used"]

[Text] China's first large critical thermal power equipment having a technology at the international level of the 1980's—the Shanghai Wujing project's first 300,000 kw generating unit—was handed over yesterday to begin power generation following trial runs as the construction project required. This demonstrates that China is ready to compete in international markets in the design, manufacture, and installation of large power plants.

The Wujing Thermal Power Plant, which is located along the Huangpu Jiang in suburban Shanghai, is one of the city's principal power plants. In accordance with world practice, tenders were called for and bids submitted internationally for this newly built two 300,000 kW generating unit plant. A consortium made up of the Shanghai Allied Electric Power Corporation, the Shanghai Electric Power Construction Bureau, and the Northwest Electric Power Design Institute won the bid, opening the way for China's large electric power manufacturing industry to enter the international competition arena.

Requirements for manufacture of equipment and construction of the Wujing project are very high. The project contract provides for a "single responsibility system," which means that only a small number of countries in the

world have the ability to design, manufacture the equipment, construct the plant and install the equipment, test the entire plant, and manage all particulars. In undertaking to build such a sophisticated power plant for the first time, China took numerous risks. In order to ensure high quality and high standards in building the project, the World Bank inspected the project twice each year. Staff members and workers of the Shanghai Allied Electric Power Corporation, the Shanghai Electric Power Construction Bureau, and the Northwest Electric Power Design Institute exhibited a spirit of unity, cooperation, and arduous struggle, pulling together as a team in designing and manufacturing the equipment, building the plant, and installing the equipment. After digesting the design principles of the American Yibasiku [phonetic] Corporation, the Northwest Electric Power Design Institute began painstaking design work. In accordance with international practice, the Shanghai Electric Power Construction Bureau provided coordination and control throughout the entire construction process, waging a very able battle to ensure the building of a large power station meeting world standards. The owners of the enterprise, the Shanghai Municipal Electric Power Industrial Bureau and the Wujing Thermal Power Plant strictly supervised contract fulfillment, and effectively organized operational control to ensure that the generating units would go into operation without a hitch.

Equipment manufactured in the Shanghai area accounted for 77 percent of the value of all equipment manufactured for the Wujing project. Seventeen key pieces of equipment for the main and ancillary generators were imported from abroad, and the patented skills of world-renowned manufacturing plants were digested and assimilated. After several years of major industrial battles and scientific and technical feats, China was able to manufacture the units itself. The turbines, generators, and boilers for the three main units were manufactured by the Shanghai Turbine Plant, the Shanghai Electrical Machinery Plant, and the Shanghai Boiler Plant, 93 percent of all the equipment being manufactured in China. For the automated control system, a monitoring and control system employing advanced modern decentralized microcomputers was used. The first generating units were manufactured entirely in accordance with quality standards and subjected to a rigorous quality guarantee system. Testing preliminary to acceptance was employed in the construction and installation of 2,598 items, 97 percent of which were found to be sound. The technical performance and the efficiency standards for all of the generating units exceed those of other domestically produced 300,000 kW generating units of the same kind.

The Wujing project is the largest thermal power construction project that China has ever contracted independently using World Bank loans, the project contract totaling $168,900,000 in value. This sets the stage for the Shanghai Allied Electric Power Corporation to enter the work market for building electric power stations. Today, following more than 3 years of efforts on the part of the builders, because of the premium quality and the on-time completion of the Wujing project's first power generating unit beside the Huangpu Jiang, the plant is hailed as a Shanghai "showcase" meeting international standards that has attracted the interest of others in the same industry both at home and abroad. World Bank officials also consider this a successful example of the use of World Bank loans by a developing country.

At the present time, the second power generating unit of the Wujing project is being feverishly built. Plans call for it to begin generating electricity in September 1992. This will play a major role in further easing the shortage of electricity in Shanghai.

Problems in Using Gangue as Power Plant Fuel Discussed

926B0056A Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese
No 11 Nov 91 pp 17-20

[Article by Fan Kai [2868 0418] of Kunming Designs Institute for Non-Ferrous Metals: "Problems in Using Gangue as Power Plant Fuel Discussed"]

[Text] Gangue has been used as a power plant fuel in China for more than a dozen years. In order to conserve energy, the government always encourages power plants to use gangue, especially tailings of coal washing plants, as a fuel. A policy was drawn up to favor the construction of gangue-burning power plants. Since the mid 1970's, many such power plants have been put into operation. After years of experimental operation, we have accumulated considerable experience and uncovered a number of problems. We are at a stage to promote the widespread use of gangue-burning power plants.

I. Status of Using Gangue as Power Plant Fuel

Based on the 1983 economic yearbook, it was estimated that gangue-burning power plants would generate 600 million kWh of electricity in China in 1988. On the average, 600 grams of coal is consumed to generate a kWh of electricity. This is equivalent to a saving of 360,000 tons of standard coal per year. If the amount of heat produced by gangue (at the base) is 8373.6 kJ/kg (2000 kcal/kg), it is equivalent to 1.26 million tons of gangue. According to available statistics, we had over 30 million tons of gangue, i.e. 20 percent of the raw coal produced in coal mines under the centralized dispatch system alone, in 1988. This is much more than is being used for power generation. It is an indication that there is still considerable work to accomplish before comprehensive utilization of gangue is a reality. As the economy grows, the coal industry is paying more attention to coal selection and washing to improve product quality. There will be more byproducts, such as washed medium grade coal and gangue, as the coal washing capacity increases. In addition, there is a considerable amount of low grade coal which cannot be washed and used in any applications. Therefore, it is an important aspect of our energy conservation program to find uses for such low heat content fuels.

As far as gangue is concerned, the Ministry of Coal Industry planned to construct 45 new gangue-burning power plants in the Seventh 5-Year Plan with a total capacity of 1 million kW. However, only 300,000 kW was completed at the end of the Seventh 5-Year Plan. Of course, lack of funding is only one of the problems. More importantly, there are still some problems associated with the gangue-burning power plant. The policy is also less than perfect. Various local authorities implemented the policy differently. These factors also adversely affected the development of gangue-burning power plants.

II. Problems Associated With Gangue-Burning Power Plants

Using gangue to generate electricity is a new application in China. If it is not economically attractive, it will not be competitive to be promoted for widespread use. Various problems associated with such plants today are essentially related to the economic benefits.

(1) The annual number of hours of operation is usually not very high.

The furnace in our gangue-burning power plant is a boiling fluidized-bed furnace. The advantage is that it is adaptive to a variety of coal, including low heat content coal. The disadvantages include: thermal efficiency is low, only 67-72 percent, poor coal-burning stability and difficulty in operation. Based on our understanding, the average operating hours of this type of furnace is 4000-5000 hours per year. Some individual power plants have a lower number. Since there are no spare furnaces, the power plants could not operate for a large number of hours per year. It is quite less than the 6000 hours specified by the Ministry of Coal Industry. The primary causes for this situation are:

1. The heat content of gangue is too low for the furnace.

It is well recognized that a boiling fluidized-bed furnace can burn low heat content coal. However, there is some controversy about what the optimum heat content should be. Our furnace is designed for 6280.2 - 8373.6 kJ/kg (1500 - 2000 kcal/kg) based on the heat content of washed gangue which is usually between 4186.8 - 8373.6 kJ/kg. Some are higher than this range. It is dependent upon the type and quality of the raw coal and the recovery rate. In reality, the heat content of washed gangue fluctuates widely. Washed gangue is the primary fuel for a gangue-burning power plant. In some plants, the fluidized-bed furnaces were designed to match with heat content of the gangue produced locally at the time. However, the furnaces face the problem of unstable combustion after they were put in operation. As far as the fuel is concerned, in addition to the heat content, other factors, such as volatile components, specific gravity and ash content, also affect the stability of combustion. Presently, many furnace makers cannot design different furnaces for individual users based on local requirements. A furnace is designed based on the gangue produced somewhere and this model is being distributed to other places as a product. Hence, if the heat content of the gangue is too low, there will be numerous adverse factors to allow the furnaces to operate stably over long periods of time. After years of operation, the conclusion is that stable combustion can be ensured when the heat content of the fuel is above 10467 kJ/kg (2500 kcal/kg).

2. Most problems are related to crushing and dehydration of washed gangue.

The boiling fluidized-bed furnace has very stringent requirements on fuel particle size and water content. The

appropriate particle size should be in the range of 1-8 mm. Particles less than 0.5 mm are usually not used. The water content should be less than 7 percent. The usual water content from ordinary gangue plants is as high as 12-16 percent and the particle size is less than 50 mm. Therefore, crushing and dehydration are required. Because the physical properties of washed gangue vary from place to place, it is very difficult for power plants to prepare the coal to burn. For example, a gangue-burning power plant in Yunnan was designed to crush the gangue first and then to remove the water by natural dehydration in a cylindrical container. In reality, the operation is problematic. The main problem is that the particle size varies widely. Usually, approximately 5 percent of the crushed gangue is below 0.5 mm in particle size. Nevertheless, more than 20 percent of the crushed gangue there is less than 0.5 mm. The power plant made some adjustment to the fuel by mixing in a substantial amount of low grade coal into the gangue. This situation was improved somewhat. However, the gangue utilization rate is still far below the target value in the design.

3. The wear and tear is high for boiling fluidized-bed furnace which leads to a high level of maintenance.

Since washed gangue is the fuel for these furnaces, the ash content is as high as 50-70 percent. The pipes, refractory brick and coal saver in the furnace are suffering from serious erosion. Furnaces need frequent repairs and maintenance.

4. The power plant management level is relatively low.

Because gangue-burning power plants are power plants owned and operated by the coal industry, they are not subject to the supervision of the power system. Consequently, they do not rigorously obey the rules and standards set by the power system. Compared to conventional power plants, gangue-burning power plants have the following disadvantages:

(1) There is a shortage of trained personnel in thermal engineering, power generation and power distribution.

(2) Workers are less qualified.

(3) There is a lack of power plant management experience.

These reasons also directly affect the annual operating hours of gangue-burning power plants. The low operating hours resulted in less power generated. The profit is low and the return of investment is not attractive.

(II) Scale of Gangue-Burning Power Plants and Grid Integration

The evaporation rate of our boiling furnace is somewhere in the range of 10-130 t/h. Most of them are at 35 t/h. They are matched with 6,000 kW steam turbine generators. Most gangue-burning power plants use 6,000 kW generator units. It is also the more mature type. The total capacity of such a power plant may be 2 x 6,000 kW, 3 x 6,000 kW and 4 x 6,000 kW, depending upon the water supply, power load and gangue production rate of the coal mine.

1. Determination of gangue quality and quantity.

The quality and quantity of gangue directly affect the scale and constraints of the power plant. Factors such as heat content, volatility, ash content, particle size distribution and specific gravity determine how useful the gangue is. This requires detailed analysis of coal quality. Physicochemical data needs to be collected over long periods of time as a function of heat content fluctuation and this information must be made available to the design department to serve as a basis for demonstrating the feasibility of a gangue-burning power plant. However this factor was not taken seriously by some coal mines. The data provided is incomplete and inaccurate. Their thought is that they have no resources to blend in raw coal if there is not enough gangue to burn. If the gangue quality is inadequate, they can blend in high grade coal. This is caused by the external factor that our policy overly stresses the use of gangue and neglects the facts that in some areas the quality of gangue is too poor to burn as a fuel for a power plant with fluidized-bed furnaces. There is a lack of rigorous review before the power plant is being constructed and a lack of effective supervision after it is put into production. In some cases, the data provided is drastically different from reality. The only solution is to blend in a great deal of coal. Because the fuel being used is quite different from that in the origin design, the process structure and equipment selection become less than optimal.

2. Grid Integration

Because we are still divided by different systems, there are contradictions which are difficult to resolve. Although the government has ordered that gangue-burning power plants can be integrated into the national power grid. If excess power is delivered into the power grid, the electric power department should only charge the cost and return the profit to the coal mine. In addition, a gangue-burning power plant can exchange electricity with the power grid and the accounting is done on a monthly basis. In reality, this policy is very difficult to implement. In some areas, it is not followed. For example, it cost approximately 0.072 yuan/kWh to generate electricity at a gangue-burning power plant in Yunnan in 1990. It only received 0.052 yuan/kWh when delivering power to the grid while it had to pay 0.122 yuan/kWh to buy power from the grid. In other words, it could not sell power to the grid at cost and could not offset the power purchased from the grid on a monthly basis. The electricity department has its view of the reasons for this. (1) Gangue-burning power plants are usually low in capacity. After supplying power to the coal mine itself, there is not much power left for the power grid. The supply is not very stable. The electric power department is unwilling to accept this kind of power. (2) Due to load fluctuation, it is very often that the peak load of the power grid coincides with the peak load at the

coal mine and vice versa. Especially in view of the fact that the government has not changed the pricing structure to differentiate consumption during peak and off-peak hours, the electric power department has a hard time accepting this kind of power swap. Based on our understanding, gangue-burning power plants are delivering power to the power grid during off-peak hours. Often, it delivers ¼ of its annual capacity. The more power it delivers to the power grid, the more money it loses. Based on the above reasons, some coal mines in coal producing areas wish to establish their own power transmission systems. Since there is a national power grid already, it would be wasteful to build another power grid. Furthermore, without the cooperation of the electric power department, it would also be very difficult to accomplish.

(III) Economic Evaluation of Gangue-Burning Power Plant

If a gangue-burning power plant operates normally, because it costs nothing to use washed gangue, the cost to generate electricity is lower than other power plants. It does have significant economic advantage. Nevertheless, over the years, coal price does not reflect its cost. Most coal mines are losing money due to policy related reasons. Despite subsidies from the government, the losses are still substantial. Since the gangue-burning power plant belongs to the coal mine, its economic benefit is directly affected. Some gangue-burning power plants do not keep independent accounting records. In order to reduce their losses, some coal mines are using the power at a low rate to switch the profits to coal production. These power plants actually showed very little profit. Some of them even showed losses. Hence, the loans cannot be paid back. Some coal mines are delaying their payments back on the construction loan. Once the reputation is ruined, it is very difficult for new power plant construction loans to get approved.

III. Outlook of Gangue-Burning Power Plants and Measures for Improvement

In recent years, a circulating fluidized-bed furnace has been developed. This furnace was developed to solve problems related to the boiling furnace, such as low thermal efficiency and high ash content. The special feature is that the chamber of the furnace is higher than that of the boiling furnace to allow the fuel to burn to completion over a longer period of time. In addition, an ash collector, i.e. a vortex separator, is also included. The ash gathered by the vortex separator is sent back down to the fluidized-bed to continue the burning process. Thus, the chemical energy loss due to incomplete combustion is minimized and the ash content in the smoke is also reduced. This arrangement improves the furnace efficiency and provides better protection to the environment. The thermal efficiency has reached as high as 86-89 percent. This furnace is in field trial now at a few sites. The furnace is designed to burn soft coal and low-grade coal. Based on the performance so far, the heat content of the fuel used is above 14,653.8 kJ/kg (3,500 kcal/kg). The actual furnace efficiency is dependent upon the combustion process. It usually ranges between 76-89 percent. Since it is still in field trial, the operation is not very smooth yet. Therefore, there are still problems in directly using gangue to fuel a circulating fluidized-bed furnace.

Based on the situation in other countries, considerable progress has been made in boiling furnace and circulating fluidized-bed furnace, particularly in areas such as high capacity and high thermal efficiency. The development of fluidized-bed furnace abroad is focused on burning high sulfur coal. Due to industrialization, environmental pollution is becoming a serious issue. The mounting quantity of sulfur dioxide discharged causes every place to suffer from acid rain to some extent. To this end, most industrialized nations have stringent standards controlling the discharge of harmful substances into the environment. As far as smoke from furnaces is concerned, ash content, sulfur dioxide and NO_x are the main items subject to such control. Since it is very convenient to put limestone directly into a boiling furnace or circulating fluidized-bed furnace for in-situ desulfurization without much added cost, it is becoming very popular. Based on information on hand, the boiling furnace and fluidized-bed furnace have been commercialized. However, the heat content of the fuel used abroad is much higher, usually above 16,747.2 kJ/kg (4,000 kcal/kg), than what we are using in our boiling furnaces.

The worldwide trend is to develop circulating fluidized-bed furnaces. This is being scaled up. Based on our understanding, the development of a 220 t/h circulating fluidized-bed furnace has been included as a national focal technical project this year. The fuel for a circulating fluidized-bed furnace is primarily low-grade coal. Its development brings a bright prospect for the low-grade coal available. On the other hand, how to make full use of gangue is also a pressing issue. Based on where we are, there is considerable experience and advantage to burn gangue in conventional boiling furnaces. A series of measures should be taken to solve the problems related to the use of gangue for power generation.

1. All studies on boiling furnace or circulating fluidized-bed furnace, in addition to addressing thermal efficiency and environmental pollution concerns, should investigate the adaptivity of the furnace to low heat content fuel. Burning gangue is already a form of recycling waste. The thermal efficiency of the furnace cannot be very high. Key issues to be addressed in the near future to perfect the operation of gangue-burning power plants are to find ways to maintain stable combustion and to reduce erosion by optimizing furnace material and structure. Manufacturers should design furnaces based on the composition of the gangue to be used.

2. The coal system should establish a dedicated organization to conduct a nationwide survey on the species, quality and quantity of gangue available. Every coal mines should cooperate to provide analysis result of the

gangue it produces. An accurate assessment should be made based on the actual data gathered to determine whether an area is suitable for the construction of a gangue-burning power plant. Furthermore, gangue-burning power plants already in operation should be monitored for quality and profitability. In the near term, gangue with higher heat content should be given priority. It is more desirable to have a heat content of over 8,373.6 kJ/kg (2,000 kcal/kg).

3. In the design of gangue-burning power plant, serious consideration should be given to match the furnace with the steam turbine generator. The number of annual operating hours is usually relatively low, approximately 5,000 hours. However, a steam turbine generator typically can operate over 7,200 hours a year. The idle time is too long. If a spare furnace is included in the design, then the situation can change drastically. Let us use a 2 x 6,000 kW power plant as an example. The original design is two furnaces and two generators. Every year the number of power generating hours is 2 x 5,000, or 10,000 hours. If an additional furnace is added, i.e. three furnaces and two generators, the number of power generating hours can be increased to 15,000 hours. To add another furnace, including the plant space it requires, only increases the investment by approximately 10 percent. However, the power generating capacity can reach 3 x 6,000 kW. The economic benefit is apparent.

4. It is necessary to clearly identify that a gangue-burning power plant is a fiscally independent entity during the approval process. The power plant supplies electricity to the coal mine at a slightly lower price compared to what the coal mine pays for electricity from the power grid in order to allow the gangue-burning power plant to make a reasonable profit. The construction loan should be paid off within 5 years, definitely no more than 10 years. We have to stress the significance of economics and work hard to raise the number of operating hours per year. With the assurance that the furnace is operating normally, we should use as much gangue as possible to reduce costs and enhance competitiveness. This is the key to solving the problem with the electric power grid system.

5. The coal system should be open and allow the electric power department to participate in the management of gangue-burning power plants. The electric power department has a complete set of management standards concerning thermal power plants. Gangue-burning power plants should be rigorously managed according to the standards set by the electric power department whenever possible. Furthermore, we must attract talented people because this is an effective way to improve the management level of such power plants.

Sino-Japanese Cooperative Prospecting Venture in Tarim Basin

926B0075B Urumqi XINJIANG RIBAO in Chinese 19 Feb 92 p 1

[Article by Reporter Sun Bin [1327 2430]: "Sino-Japanese Tarim Basin Prospecting Project Moves Along Smoothly. First Shipment of Equipment From Japan Reaches Urumqi"]

[Text] Urumqi Dispatch: The geological and global physics prospecting project underway in the Kashi-Yecheng area of the Tarim Basin in Xinjiang in which the State Council is directly interested, which was jointly contracted by the Joint Team of the Geology Survey Department of the Xinjiang Petroleum Bureau with the China Petroleum and Natural Gas Corporation and the Japan Petroleum Consortium, and in which Japan invested 8 billion yen recently entered the substantive stage of cooperative implementation with the arrival in Urumqi of the first shipment of production equipment from Japan.

This project got underway following the signing in Beijing on 5 July of the "Basic Agreement on a Petroleum Geology and Geophysical Survey in the Kashi-Yecheng Region of the Tarim Basin in China" between the general manager of the China Petroleum and Natural Gas Corporation, Wang Shou [3769 1108], and the Japan Petroleum Consortium. The survey is being conducted by the Joint Team of the Geology Survey Department of the Xinjiang Petroleum Bureau. In conscientious implementation of this agreement, the Chinese and Japanese personnel engaged in the project personally went to the Kashi-Yecheng region to conduct an on-site survey to find out in detail about transportation, medical services, the climate, the selection of a base, and the availability of water for production and daily life when construction begins. They made a detailed survey of the region's terrain and topography, and took samples from rock outcroppings.

While conducting the survey, the personnel from both sides spent the past half year on full discussions about the administrative and technical aspects of the cooperative prospecting venture as spelled out in the agreement. They also did preliminary planning on equipment, personnel, expenses, transportation, and seismic wave measurements, and reached agreement about a preliminary geological assessment of the area, the geological goals of the survey, as well as some of the problems that might be encountered in the survey and means of solving them. Formation of the team has now been completed, and the operating stage is at hand.

Will Inland Oil Fields Open Up to Foreign Developers?

40100032 Beijing CHINA DAILY (Business Weekly) in English 4 Apr 92 p 1

[Article by Chang Weimin]

[Text] China is believed to be considering whether to open up its inland as well as offshore oilfields to foreign firms.

Officials from these firms told Business Weekly that they are eager to help develop oil-bearing areas in basins in the Xinjiang Uygur Autonomous Region, where oil reserves are so large that they are expected to become the country's main supply base.

It was confirmed last week that the continental shelf, with water no deeper than 5 meters, is likely to be opened up to foreign oil companies for exploration.

Also likely to be thrown open is the East China Sea, where rich oil and gas resources are expected to be discovered, to add substantially to the country's confirmed reserves.

A lot of foreign equipment has been used in the Tarim, Turpan-Hami and Junggar basins in Xinjiang, where huge reserves of oil have been confirmed, but no foreign firms have, so far, been promised access to petroleum development there.

A Shell manager has said: "We want to enter Tarim," and analysts say foreign oil firms' expectations have risen following Deng Xiaoping's tour of South China early this year, when he reportedly urged bolder steps to accelerate reforms and opening up to the outside world.

China opened the South China Sea to foreign oil firms in 1982 and since then at least $3.13 billion of foreign investment has been used there. Both Chinese and foreign firms have made money.

China also opened some areas in 11 provinces in the south and now three contracts on cooperation with foreign firms are being implemented.

However, Roger Abel, president of the Society of Petroleum Engineering, a high-profile international organization based in the United States, says foreign firms' activities in inland areas are limited.

There would be benefits both for China and its partners if it opened up the areas where there are known to be enormous oil and gas reserves, Abel said.

China National Petroleum Corporation has already started preparations so that it can go into action quickly as soon as the government's decision on opening the continental shelf is announced.

Asked about the possibility of opening the three basins in Xinjiang to foreign oil firms, a CNPC official said that China would not be likely to take such a bold step at present.

The China National Offshore Oil Corporation now has more than 40 contracts on cooperation with foreign firms in hand and expects to sign another eight this year.

On March 22, the day before the fourth international meeting on petroleum engineering, and the international

petroleum technology and equipment exhibition opened in Beijing, the Society of Petroleum Engineering established its first Chinese section in the city.

New Round of Petroleum Industry Contracting

926B0061A Hefei ANHUI RIBAO in Chinese 20 Jan 92 p 3

[Article by Zhu Youdi [2612 1635 2769] and Zhang Chaowen [1728 6389 2429]: "China's Petroleum Industry Enters New Round of Contracting. Zhu Rongji [2612 3579 1015] Conveys Warm Regards to the Petroleum Front Line on Behalf of Premier Li Peng"]

[Excerpts] Xinhua She, 18 January. Deputy Premier Zhu Rongji met delegates to the All-China Petroleum Industry Bureau's Conference of Leading Plant Cadres at Zhongnanhai this afternoon. In a speech, he affirmed the accomplishments made in the country's petroleum industry during the past year, and conveyed the warm regards of Premier Li Peng to the broad masses of cadres, scientific and technical personnel, and working comrades on the petroleum front line.

Guided by the CPC Central Committee's and State Council's strategic plan for "steadying the east and developing the west," oil and gas production in the nation's petroleum industry nationwide has seen consistent increase since 1991. In 1991, the country produced 139.76 million tons of crude oil and 15.4 billion cubic meters of natural gas in the initial achievement of balanced and consistent output according to plan, a situation unprecedented in recent years. The country's 20 on- shore oil fields either fulfilled or overfulfilled production plans. Oil exploration also improved. Gas prospecting was steadily intensified and extended to new fields, some major finds being made. Both oil and gas reserves increased as the number of oil and gas fields discovered steadily expanded.

During the past 10 years, contracting by the country's petroleum industry has produced sustained and steady development. At today's conference, the director of the China Petroleum and Natural Gas Corporation, Wang Tao [3769 3447], signed a new round of contracts with leaders of 17 petroleum management bureaus and petroleum prospecting bureaus, including those at Daqing, Shengli, Liaohe, Zhongyuan, Xinjiang, North China, and Dagang. The China Petroleum and Natural Gas Corporation announced that it will deliver all pertinent state policies to on-shore oil fields, with the exception of the three major oil fields at Daqing, Shengli, and Liaohe, requiring them to carry out reforms, and become responsible for profit and loss. The leaders of these oil fields said that during the coming year they will spur the sustained, steady development of the country's petroleum industry through the intensification of reform and increased openness. [passage omitted]

In his summarization speech at the conference Wang Tao said that the main task of China's petroleum task in the future will be to move ahead from continued vocational contracting and perfection of the contract responsibility system to changing the operating mechanism, readjusting the internal structure, and smashing "iron rice bowls, iron arm chairs, and large common pots" in order to spur changes from production type to operating type petroleum enterprises. The petroleum industry has to learn to swim in the ocean of a planned commodity economy.

Director Wang Tao noted that in the new round of petroleum industry contracts, the correlation among reform, development, and stability will have to be handled diligently. We will have to depend wholeheartedly on the working class for the development of production, for increase in the value of state assets, for enterprise returns, and for staff member and worker earnings. [passage omitted]

Characteristics of Oil-Gas Pools and Hydrocarbon Distribution in the Turpan-Hami Basin

926B0062 Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 12, No 4, Dec 91 pp 351-363

[Article by Zhao Wenzhi [6392 2429 2535] and Li Wei [2621 0251] of the Beijing Petroleum Exploration and Development Scientific Research Academy Geology Institute and Yan Liecan [3601 3525 3503] of the Yumen Petroleum Management Bureau Exploration and Development Research Academy: "A Preliminary Probe Into Oil and Gas Pool Categories and Characteristics and Distributional Laws of Oil and Gas in Turpan-Hami Basin"; manuscript received 26 February 1991, revised and returned 5 April 1991]

[Text] Abstract: With a prerequisite of delineating the oil and gas pools in Turpan-Hami Basin into three basic categories of structural, stratigraphic-lithologic, and compound types, each category of oil and gas pool can be further classified according to the relationship between oil and gas in-migration and trap formation into comatured plentiful type, semi-comatured non-plentiful type, comatured but subsequently destroyed type, and non-comatured poor type oil and gas pools. The accumulation of oil and gas was subject to control by paleouplifts, paleoslopes, fracture zones, and strata erosion pinch-out belts, so they have the characteristics of compound oil and gas accumulations.

Key terms: Turpan-Hami Basin, oil and gas pool categories, oil and gas distribution laws

First author introduction: Zhao Wenzhi, male, 33 years of age, engineer (Masters'), petroleum geology and exploration

Major breakthroughs have been made since 1986 in oil and gas exploration in Turpan-Hami Basin and four large and medium-sized oil and gas fields have been discovered there which control extremely substantial petroleum geological reserves. The authors have been

involved in research on the petroleum geology characteristics and oil and gas distribution laws in this basin since the end of 1986. We have discovered that many aspects of its petroleum geology characteristics were not fully understood from exploration during the 1950's and 1960's. Moreover, a new understanding of these areas has played a major role in rapid breakthroughs in oil and gas exploration in the basin. This article begins with an analysis of the unique properties of already discovered oil and gas pools and summarizes the oil and gas pool categories and characteristics of the basin, and it explores the basic laws of oil and gas accumulation and distribution based on the interrelationships of structures, sediments, and oil and gas generation, migration, and accumulation.

I. Regional Geological Background and Basic Geological Conditions

Turpan-Hami Basin is one of three large sedimentary basins within the boundaries of Xinjiang and covers an area of about 48,600 km^2. It can be divided on the basis of geological structures into large eastern and western depressions and an intermediate uplift. The western part is called the Turpan depression and covers an area of about 21,000 km^2. The eastern part is called the Hami depression and covers an area of about 15,000 km^2. The central part is called the Liaodun uplift and covers an area of 12,500 km^2. New seismic data indicates that Liaodun uplift is uplifted to the south but not to the north and that the northern part is a channel connecting the eastern and western depressions. Turpan-Hami Basin is filled with continental facies sediments from the Permian to Quaternary systems and the maximum thickness of the sediments is more than 8,700 m. The Turpan depression is primarily from the Jurassic system but the Permian and Triassic systems also developed there and they form an asymmetrical configuration that is thick in the north and thin in the south with northern faults and southern overlap. The Hami depression is primarily the Triassic and Permian systems but the Jurassic system also exists. The maximum thickness of sediments there exceeds 6,000 m.

The primary oil generating strata in Turpan-Hami Basin are the lower Jurassic system Badaowan group (J_1b) coal series, middle Jurassic system Qiktim group (J_2q), upper Permian system Tarlang group (P_2t), and middle and upper Triassic system Xiaoquangou group ($T_{2+3}xq$) deep to semi-deep lake facies mudstone. The main reservoir strata is sandstone from the same periods that lies between and alternates with these oil generating strata. It has been confirmed that the primary oil-bearing strata are the Jurassic system Xishanyao group (J_2x), Sanjianfang group (J_2s), and Qiktim group and the middle and upper Triassic system Karamay group ($T_{2+3}k$) group (Figure 1 [not reproduced]).

Local structures are extremely well-developed in Turpan-Hami Basin. Some 72 local structures have already been discovered, mainly anticlines and fault- anticlines, which account for 81.9 percent of the total number. They are distributed in clusters and belts and their development is concentrated in the basin's seven large fault-anticline zones. The generation of most of the local structures is related to the effects of shear-compression thrust faulting and the earliest were formed at the end of the Triassic. The large-scale formation occurred at the end of the Jurassic and end of the Tertiary. The formation and migration of these local structures are characterized by regularities of developing from the paleouplift toward the middle of the depression. Thus, most of the paleostructures are paleouplifts and paleoslopes in alternating positions, whereas there are mostly new structures within the depressions. The local structures often manifest characteristics like high amplitude, asymmetry of the two flanks, unconformity of the high points of deep and shallow strata, varying degrees of thickening in the central part of plastic strata, and so on. They can be classified into normal flower-shaped, reverse rotation, shear anticline, drag anticline, thrust fault anticline, short-axis anticline, and other structural types that are united within the three large structure combinations of shear, thrust faulting, and bedrock uplifting.

II. Trap Categories and Geological Conditions of Oil Formation

The traps in Turpan-Hami Basin can be divided based on the principle of integrating formation and shape into three main categories and 15 small categories (Table 1). Among them, structural trap types predominate, followed by structural-lithologic compound types and lithologic types. Most of the structural traps are anticlinal traps, and among them shear-compression anticlines and fault-anticlines hold the superior position.

One of the keys to whether or not oil and gas accumulated in the traps is the interrelationship between trap formation and the maturity and migration of the oil and gas. Of course, the position of the traps also determines the opportunity for the traps to receive oil and gas. Thus, this article uses the three concepts of comatured, semi-comatured, and non-comatured to indicate the three types of conditions of the occurrence of trap formation and oil and gas maturation and migration at the same time, slightly later, and much later to represent a series of changes from substantial to limited opportunities for the traps to receive oil and gas.

1. Comatured-type traps: This refers to trap formation that occurs simultaneously with or in advance of oil and gas maturation and large-scale discharge. In Turpan-Hami Basin, the traps in this category formed early and also have rather good paleostructure and new structure overlap conditions. Moreover, the traps are located in the primary routes of oil and gas migration. Regarding their formation, most of the traps in this category were formed during the late Jurassic or even earlier. Regarding their distribution, most are located in structural zones on a background of paleouplifts between and at the margins of oil generating depressions.

Table 1. Categories and Characteristics of Traps in Turpan-Hami Basin

Category				Primary characteristics	Examples
Main category	Basic type	Subcategory	Detailed category		
Structural traps	Anticline type	Pure compression anticlines	Integral anticlines	Linear shape, compact, high amplitude, asymmetrical	Bogda premontane anticline
			Reversed anticline	Linear shape, one flank a fault that is dissected and reversed, great displacement of high points of deep and shallow strata, devastating destruction, footwall developed drag anticline	Huoyan Shan anticline
		Shear-compression anticline	Reversed anticline	Moderate to gentle amplitude, located in oil generating depressions, good matchup of generation and reservoiring traps	Shengbei, Singim anticlines
			Normal flower-shaped structure	High amplitude, deep, moderate, and shallow enclosure areas forming small, large, and small date-pit shapes, plastic strata thicker and broken in central parts, many high points	Kekeya, Qiuling, Hongshan anticlines
			Shear fracture anticlines	High amplitude, many high points, form echelon-shaped rows, distributed on the upthrust side of faults, dissected near one flank of faults	Yilahu, Yanshankou No 2 anticlines
			Shear anticlines	Plastic strata thicken in center, with some penetration, series of high points form echelon-shaped rows	Sishili Dadun Nos 1, 2, 3
		Bedrock growth anticlines	Bald-headed structures	Broad, gentle, high amplitude, equiaxial, large area	Takequan, Kendeke
			Short-axis anticlines	High amplitude, equiaxial, weak destruction	Shanshan (Piqan) anticline
	Fault-block type		Fault nose	Sealing of faults depends on lithologic combination at time fault was created and cut-off fault	
			Fault-block		Wenjisan, Bakan
Stratigraphic-lithologic traps			Stratigraphic unconformity	In the western depression, most are capped by the Tertiary and were created late; in the eastern depression, most are capped by the Jurassic and were created early	Burjia Nos 1, 2, Kendeke strata
			Strata overlap		
			Hydrocarbon plug	Oil strata outcrop at surface, laterally subject to lithologic closure, small scale	Qiktim
			Lithologic	Not subject to structural control, alternate with oil generating strata	Shanshan oil field Sanjianfang lower oil group
Compound traps			Structural-lithologic	Not subject to control by high points, distributed on slope positions on the flanks of structures	Sinjinkou, Taoergou

2. Semi-conatured type traps: This refers to traps that formed slightly later than the period of oil and gas formation and large-scale drainage or at the time the oil and gas matured and was discharged in large amounts. The structure amplitudes are relatively small and no oil and gas re- migrated in after the formation of structures

on a large scale. A prominent characteristic of this category of traps is that the closure area and closure amplitude are both very large but their oil charge is usually not plentiful and they tend to be large structures with small oil pools.

3. Non-comatured type traps: This refers to traps that were formed much later than the period of oil and gas maturation and large-scale discharge or traps in positions very distant from the primary direction of oil and gas migration, so there is a very small probability that they received oil and gas. There are quite a few traps of this category in Turpan-Hami Basin. The large number of traps formed during the Xishan period fall into this category if they did not overlap paleostructures.

III. Basic Categories and Characteristics of Oil and Gas Pools

To fully reflect the unique characteristics of oil and gas accumulation and oil and gas pool formation in Turpan-Hami Basin, on the basis of observing the oil pool classification principles of predecessors, the interrelationship between the oil and gas migration and trap formation periods were included in the oil pool categories. Thus, the basic categories are divided into categories by trap formation factors, shapes, and sheltering conditions and into subcategories according to the interrelationship between the periods of trap formation and oil and gas maturation and migration. In this manner, each basic type can be divided into comatured plentiful type, semi-comatured non-abundant type, comatured but subsequently destroyed type, and non-comatured poor type oil pools (Figure 2 [not reproduced]).

A. Comatured plentiful type oil and gas pools

In this category are traps whose development was basically complete when the hydrocarbon source rock around the traps began to mature and entered the hydrocarbon discharge and migration period. During the subsequent process of multiple periods of trap reinforcement, they were still replenished by oil and gas. In summary, there is an excellent match between their trap development history and oil and gas maturation and migration history. Their characteristics are: 1) A high degree of oil pool filling and large oil column height; 2) Traps are near oil sources and occupy paleouplift positions, and received oil and gas supplies over long periods and on many occasions; 3) Excellent matchup of generation, reservoiring, capping, entrapment, migration, and accumulation, with a generation and reservoiring combination that is a lateral formation type of generation and reservoiring in the same rock or generation below and reservoiring above; 4) Multiple strata systems supplied the oil and gas and there were abundant oil sources. There are three oil pools in Turpan-Hami Basin, the Shanshan, Qiuling, and Wenjisang, that have been confirmed to be oil and gas pools that fall into this category. The first two have an oil column height of more than 316 to 800 m. There are also oil and gas accumulations awaiting discovery and confirmation in the Sidaogou, Kekeya No 2, Youka No 2, and other traps.

Shanshan oil pool is a plentiful type anticline oil pool. The results of evaluation of exploratory drilling indicate that the entire scope of the structure is full of oil and gas and that the oil strata may penetrate faults and connect with Qiuling oil pool to the north. The oil column height is 209 to 316.1 m. Thus, analysis of the formational process and characteristics of Shanshan oil pool would be extremely enlightening for understanding the basic characteristics of comatured plentiful type oil and gas pools.

Shanshan oil pool is located about 28 km northeast of the Shanshan County seat on the Shanshan structure (formerly called the Taibei structure) at the southeast end of the Kekeya-Shanshan anticline zone. There is a reverse fault with at NE strike on its northwest side that separates it from Qiuling oil pool, but the oil strata in both oil pools are connected and the oil and water systems are unified.

The first discovery well in Shanshan oil pool was the Taican-1 well. This well produced an industrial oil flow with a daily output of 25.9 m^3/d when logged on 5 January 1989. The generation strata was the Jurassic system Sanjianfang group, followed by the Qiktim group. The Xishanyao group also produced an industrial oil flow.

The characteristics of Shanshan oil pool are "three larges, two highs, and four lows". "Three larges" refer to the great thickness of the oil strata, the large amplitude of the traps, and the great height of the oil column. "Two highs" refer to the high oil-gas ratio and high elastic recovery rate. "Four lows" refer to the low oil strata pressure, low reservoir strata permeability, low crude oil specific gravity (0.82 to 0.812), and low oil-bearing saturation. This is particularly true for the great oil column height, which is a unique characteristic of its plentiful oil charge. After nearly 20 exploratory wells, assessment, and confirmation, there is no interbedded water in an oil-bearing well section several 100 m long, so it has a unified oil-water boundary (Figure 3), indicating that it has integral oil-bearing characteristics.

Shanshan structure was strengthened and given final shape by the effects of shear-thrust during the Xishan period and is located between the Taibei and Qiudong depressions. Analysis of its sedimentation history indicates that for at least the Xishanyao period during the middle Jurassic era, the sedimentation system within the scope of the structure indicates that above-water sediments predominated and it would appear that the rate of subsidence within the scope of the structure was lower than the supply rate of sediments so obvious paleostructures exist. As a result, sand bodies developed nearby to the right and left. Analysis of the history of the structure's depth of burial indicates that this structure was

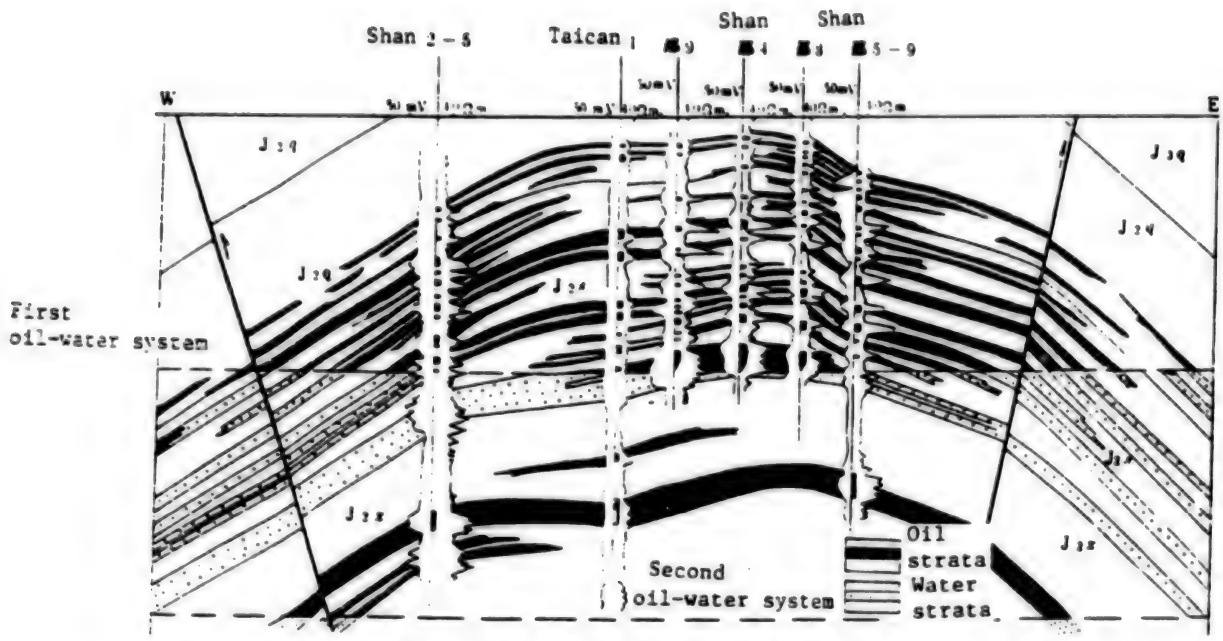

Figure 3. Shanshan Oilfield Shan 2-5 Well to Shan 5-9 Well Oil Pool Cross-Section

formed relatively early. Figure 4 [not reproduced] illustrates the geological conditions of oil formation in Shanshan structure. This article uses differences in the burial history curves of the oil supply region and top of the structure to analyze the formation periods of the paleostructure. In the illustration, the lines with dots represent the subsidence curve of the oil supply region while the solid lines reflect historical changes in burial of the top of the structure. It is easy to see from the differences in the slopes of the two curves that Shanshan structure had at least been created by the late Jurassic. The right half of the figure analyzes the oil and gas maturation history. Taican-1 well in the top of the structure determined the oil generation window limits and a reverse inference is made about the earliest period of oil and gas maturation and hydrocarbon discharge in the oil generation region. One can see that the lower Jurassic system Badaowan group oil generating strata had at the least matured and discharged hydrocarbons during the late Jurassic. Shanshan structure had already been formed by that time so it was quite natural for the oil and gas to migrate here. Comparison of oil sources indicates that the oil and gas in Shanshan oil field came mainly from the Badaowan group and that it was generated in lower rock and reservoired in upper rock. Thus, at the end of the Jurassic, the scope of the structure had an excellent matchup of reservoiring, entrapment, migration, and accumulation. We also noted that the backwater of the lake basin during the Qiktim period covered the Shanshan structure. Thus, after Jurassic sedimentation, the scope of the structure had uplifts as well as reservoir strata and had oil sources as well as preservation conditions. This is the basis for the formation of excellent accumulations in Shanshan structure.

During multiple instances of tectonic movement at the end of the Jurassic, the end of the Cretaceous, and during the Xishan period, the Shanshan structure was reinforced and never destroyed, so the structural amplitude was increased again. During this process, there may have been several main periods of oil and gas migration toward this region, but the migration never ceased from beginning to end. According to TTI research, the Jurassic system hydrocarbon source including the Qiktim group is still migrating today and has never stopped. Thus, the structural background and the concentrated development of reservoir rock, the regional capping strata and the reinforcement of the traps, the preservation conditions and the long-term migration process determined the formation of block-shaped oil and gas pools with high oil columns and high abundance in Shanshan structure.

The above analysis shows that plentiful-type oil and gas pools are related to favorable aspects in every area of oil and gas accumulation. At the same time, it also shows us that we should treat the entire Kekeya-Shanshan anticline zone as a unified oil and gas accumulation zone. First, a unified oil and gas accumulation combination with a series of high points moving from low to high may have formed running from Shanshan through Qiuling and on to Kekeya. A gas top with this combination exists in Kekeya anticline (Figure 5). Second, because the primary activity of the two sides that support this anticline zone on the sloping thrust faults was during the Xishan period, there should be some residual oil pools after being dissected on the footwall of these two side faults and the scale of the oil pools there may be even larger.

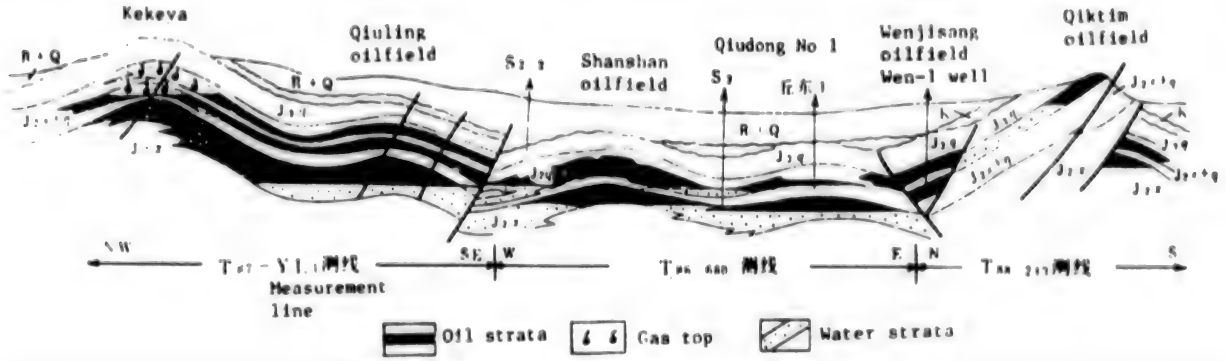

Figure 5. Kekeya-Shanshan-Qiktim Oil Pool Model

B. Semi-comatured non-plentiful type oil and gas pools

These are traps that were not fully developed and of limited amplitude when the hydrocarbon source rock surrounding the traps matured and began discharging large amounts of hydrocarbons. After the traps were further reinforced, there was no oil and gas to replenish them so the traps do not have abundant charges of oil. Their characteristics are: 1) Trap closure areas and amplitudes are both relatively large, but the oil-bearing area and oil column heights are both rather small; 2) The traps are relatively distant from oil sources and have a rather scant relationship to the primary direction of oil and gas migration and discharge; 3) The matchup of generation, migration, accumulation, and trapping conditions is less than ideal; 4) The generation and reservoiring capping combination is mainly generation in older rock and reservoiring in newer rock, with generation below and reservoiring above and a lateral generation pattern. The oil pool in this category that has been discovered already in Turpan-Hami Basin is the Yilahu oil pool. The Yanshankou No 2, Kendeke, Yarhu, and other structures also may have this category of oil pools that await further work.

Yilahu oil pool is a typical non-plentiful type fault-anticline oil pool. This has been confirmed by one exploratory well and two evaluation wells. Yilahu oil pool is located in the hanging wall of the Toksun north thrust fault, which has a NE strike, in the Yilahu anticline at the extreme southwestern end of the Yilahu-Yanshankou anticline zone, about 45 km from the Toksun County seat. This oil pool was discovered at the Tuocan-1 well, which was finished on 16 May 1989. A high-output oil flow with a daily output of 40 m^3/d was obtained from the middle and upper Triassic system Karamay group. Comparison of oil sources indicates that the oil and gas came from the Permian system.

The basic characteristics of Yilahu oil poor are "two larges, four highs, two lows, and four smalls". "Two larges" refer to the great total thickness of the reservoir strata (the total thickness of Triassic system sandstone and sandy conglomerate is 175 m, equal to 45 percent of the thickness of the strata group) and large trap amplitude (245 m). "Four highs" refer to the high strata pressure (strata pressure coefficient 1.05), high oil strata porosity and permeability (15.6 percent, 60.9 X 10^{-3} to 400 X 10^{-3} μm^2), and high single well output. "Two lows" refer to the low crude oil specific gravity (0.834) and low oil-gas ratio (49.5 to 53.7 m^3/t). "Four smalls" refer to small oil column height, small oil strata thickness, small oil-bearing area, and small geological reserves. Interpretation of electrical logging and oil tests confirm that there are a total of three oil strata, but the thickness of the oil strata is just 15.6 percent of the thickness of the sandstone. Moreover, there is obvious bottom water in each of the oil strata (Figure 6).

After analyzing the basic characteristics of Yilahu oil pool, it was discovered to have some unique properties. First, the area and amplitude of Yilahu anticline are both rather large but the discovery well revealed that the structure does not have a plentiful charge of oil, its oil charge being less than 40 percent. Second, Jurassic system structures are intact and there is no absence of reservoir strata, but they do not contain oil and may even have very weak indications of oil and gas. If the oil and gas migrated into the Jurassic system structure after its formation and came from the structure itself, the Jurassic system should have oil and gas.

Based on these conditions, the following analysis can be made of the formation process of Yilahu oil pool.

The Yilahu structure is a paleostructure whose earliest formation occurred at the end of the Triassic. However, the results of analyzing eroded strata and the qualities of several instances of tectonic movement since the mid-Mesozoic indicate that the formational period of this structure was during the Jurassic era and Xishan period. The oil generation window limits determined by the Tuocan-1 well was used to make a reverse inference of the earliest maturation and hydrocarbon periods of the oil supply region and it was determined that at the latest, the oil and gas in the Permian system had already matured and been discharged at the end of early Jurassic sedimentation (Figure 7). Although there was a structure at Yilahu at this time, its amplitude was limited, as was

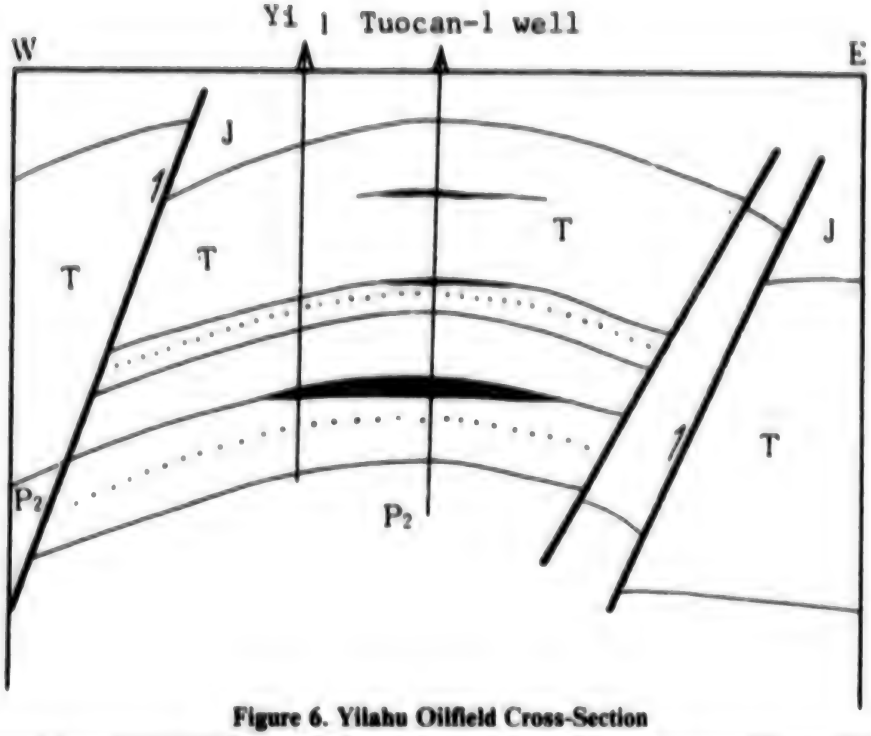

Figure 6. Yilahu Oilfield Cross-Section

the number of times it had received oil and gas. At the time of large- scale structural formation at the end of the Jurassic, however, the new Toksun north thrust fault zone also formed between it and Toksun depression. The second step in the reverse thrust zone impeded the re-migration of oil and gas into the structure. This is the key to the less than abundant charge of oil in Yilahu structure.

This analysis aids in assessing the oil-bearing properties of a series of structures in the entire Toksun north thrust fault anticline zone and shows that the second step in Toksun north thrust fault zone may have good oil-bearing properties.

C. Comatured but subsequently destroyed type oil pools

This refers to traps that formed simultaneously with oil and gas maturation and migration, but after the oil and gas accumulated, the oil and gas that had already formed was destroyed and readjusted by tectonic movement and fracturing activity and reached a new equilibrium in a new environment. The characteristics of this category of oil pools are: 1) Many or few oil and gas indications at the surface, even the appearance of some thick oil strata; 2) The degree of rich accumulation of oil and gas became poorer because of dissipation, but several ancient oil pools that were not destroyed are preserved on the footwalls of faults with a rather good degree of rich accumulation; 3) The action of groundwater and free oxygen on the top parts of oil pools caused the oil and gas to thicken and form hydrocarbon plugs or structural-lithologic traps that are thick above and thin below or thick on the top and thin on the flanks; 4) The distribution of oil and gas became more complex. The Sinjinkou and Qiktim oil pools discovered in Turpan depression during the 1950's belong to this category. Moreover, there is a possibility of this category of oil pools in the Bogda premontane anticline, Hongshan, and other structures.

The objective in analyzing comatured but subsequently destroyed type oil and gas pools is to search for and discover oil pools that have not been destroyed so far and still exist.

Sinjinkou oil pool is representative of this category of oil pool. Analysis of its formation and change processes is extremely enlightening in making breakthroughs in the search for oil in the entire central anticline zone in Turpan depression.

Sinjinkou oil pool is located on the slope around the east of Sinjinkou anticline in the western section of the Huoyan Shan anticline zone. The surface anticline has a reversed shape that is steep in the south and gentle in the north. The upper part of the Jurassic system and the Cretaceous and Tertiary systems outcrop in the central part. Beneath the surface, it is a fault-anticline whose southern flank is dissected by a thrust fault. Calculated on the basis of the -600 m sealevel contour line of the structural map of the top part of Qiktim oil strata, the closure area is 7.8 km^2 and the closure amplitude is 800 m. There is also a group of normal faults with NW strikes at the top of the structure that run nearly parallel with the long axis of the structure. The separation is generally

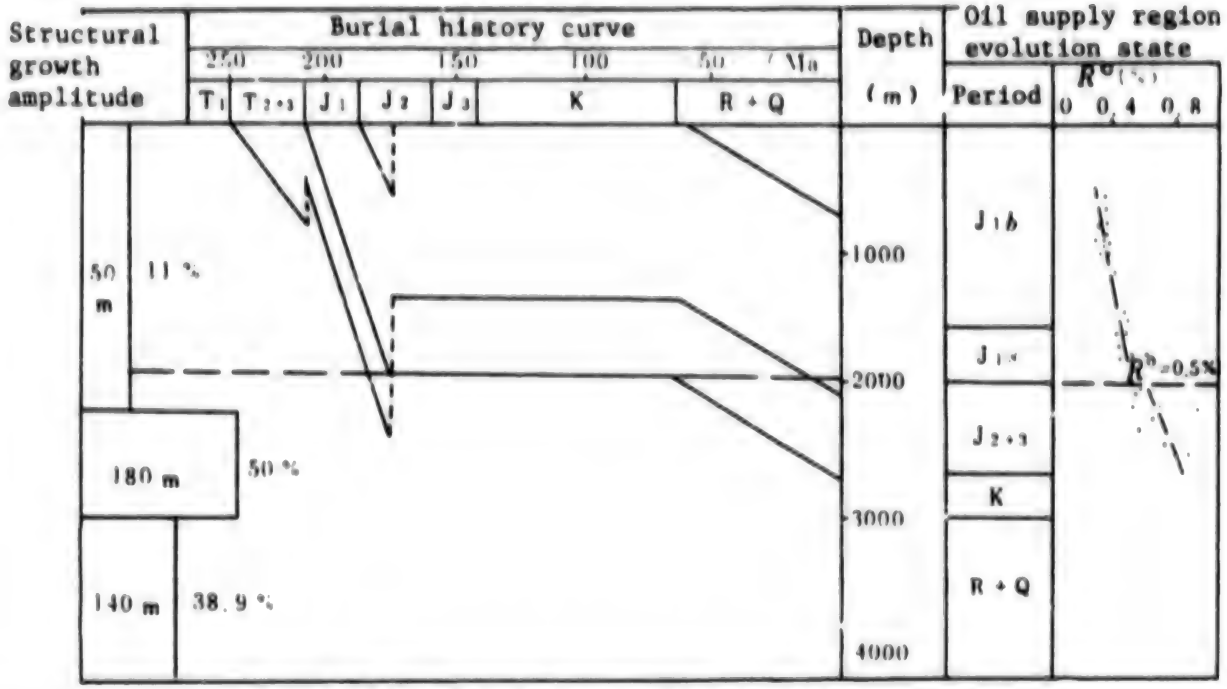

Figure 7. Yilahu Oil Pool Oil Formation Conditions Distribution Chart

< 10 m and the maximum is 130 m. A fractured and broken zone in the central part of the structure gives the main body of the structure open characteristics. There is also a complete anticline structure on the footwall of the fault on the southern flank of Sinjinkou structure.

The true Sinjinkou oil pool is a structural-lithologic trap on the slope around the east of the underground Sinjinkou structure that was formed because of lithologic sealing on a structural background (Figure 8). This oil pool was discovered in November 1958 and the discovery well was the Sheng-4 well. The daily output of crude oil was 18 m^3/d in the initial test. The primary oil strata are the Jurassic system Qiktim group followed by the Sanjianfang group.

The basic characteristics of Sinjinkou oil pool are also "three larges, two highs, two smalls, four lows, one fast, and one dissipation". "Three larges" refer to a large total thickness of reservoir strata (78 m), large entrapment area (7.8 km^2), and large amplitude (800 m). "Two highs" refers to a high oil-gas ratio (450 to 700 m^3/t) and high initial output from the oil well. "Two smalls" refer to a small oil-bearing area (accounting for 18 percent of the area of the trap) and small oil strata thickness (accounting for 20.8 percent of the total thickness of the reservoir strata). "Four lows" refer to low oil strata pressure (oil strata pressure coefficient 0.97), low specific gravity of the crude oil (0.816), low permeability of reservoir strata (2 X 10^{-3} to 18 X 10^{-3} μm^2), and low oil-bearing saturation. "One fast" refers to the rapid gradient of oil well output. "One dissipation" refers to the small single strata thickness and large number of strata (24 strata) of the reservoir strata with rapid lateral pinch-out, bifurcation, and merging.

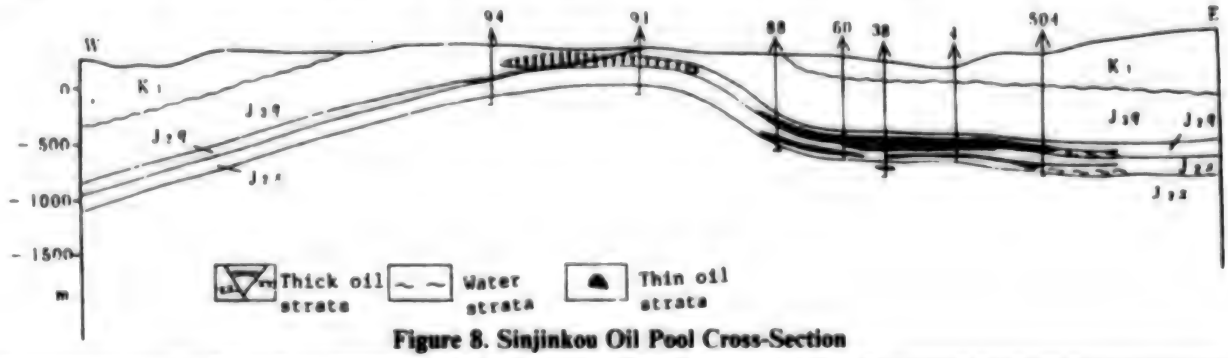

Figure 8. Sinjinkou Oil Pool Cross-Section

The successor to Sinjinkou oil pool was Taibei deep depression. This was the primary oil generating depression in Turpan depression. Its history of subsidence shows that the Jurassic system Qiktim group in the depression had already been buried at a depth of more than 3,000 m during the middle and later periods of Cretaceous sedimentation and that were was undoubtedly mature oil generation, whereas the period of lower Jurassic system Badaowan group oil generating rock maturation and discharge may have occurred even earlier. Comparison of oil sources indicates that Sinjinkou's oil and gas came mainly from Jurassic system Qiktim group lake facies oil generating rock and that the oil and gas accumulations were generated and reservoired in the same rock. However, Sinjinkou anticline obviously was formed by the effects of thrust faulting during the Xishan period and it is very clear on the surface that the structure's formation period did not match its oil and gas maturation and discharge period. Nevertheless, analyzing the surface Sinjinkou anticline and the concealed anticline structure buried on the footwall of the modern fault as a single entity shows that the entire Sinjinkou structure was created at least by the late Jurassic or even earlier. This is confirmed by the following aspects: 1) There are huge differences in thickness of the Jurassic system on the southern and northern sides of the central anticline zone. The thickness in the northern part is nearly double that of the southern part. The primary cause of the difference in sediment thickness is an obvious thickening of the middle and upper Jurassic system including the Sanjianfang group in the northern depression region. It would appear that the central anticline zone was a key zone for alternation and transition in the northern and southern sedimentation systems after the middle Jurassic. 2) Analysis of the sedimentation environment of the Sanjianfang and Qiktim groups indicates that the central anticline zone is an alternation zone between the southern above-water and northern underwater sedimentation environments. Most of the deltaic sand bodies are distributed along this zone, so there should be a background of "ancient high points". Thus, the ancient Sinjinkou structure located at high parts of the southern side of the Taibei depression should be a primary position for oil and gas migration and accumulation. The interrelationship of oil and gas maturation to structure formation and development in the depression region would seem to indicate that there is an extremely great possibility that oil and gas accumulations existed in the ancient Sinjinkou structure before it was dissected during the Xishan period.

Intense compression during the Xishan period transformed structures from previous periods, causing the northern flank of the paleostructure to be dissected and carried upward and to be inverted. At the front margin of the upthrust block, the rock strata were arched and formed extension fractures, which created a group of normal faults extending from the oil strata to the surface, causing the oil and gas that had already accumulated to be dissected and undergo readjustment. Part of the oil and gas was destroyed and some re- accumulated in the new environment. The area near the normal fault zone at the top of the modern-day structure may have generated water and no oil or the rock cores may contain oil but not produce oil. The strata water, however, is typical $CaCl_2$ oilfield water with a very high degree of mineralization. Thick oil was also produced toward the eastern part between the broken zone at the top and the thin oil pools, and the crude oil has a specific gravity of 0.937 and a viscosity of 16 to 40 MPa. All these would appear to be traces left behind by the destruction of ancient oil pools. Thus, this article views Sinjinkou oil pool as a comatured but subsequently destroyed type structural-lithologic oil pool. Besides explaining that the reason Sinjinkou oil pool is not charged with plentiful oil was because subsequent destruction caused the oil and gas to dissipate, this inference even more importantly submits for attention the possibility of an even higher oil charge abundance and even larger scale ancient oil pools on the footwall of the modern-day Sinjinkou anticline. This conclusion conforms to the analysis of the oil-bearing properties of the footwall of the entire central fracture-anticline zone.

D. Non-comatured poor-type oil and gas pools

These refer mainly to the lack of development of traps after maturation of the hydrocarbon source rock and large amounts of discharge around traps. Thus, their conditions for receiving oil and gas accumulations were rather poor. The "poor" in this category refers to the very small scale of oil and gas accumulation and mainly concerns oil and gas still being generated and migrating during the Xishan period or oil and gas that re-migrated from oil and gas pools that were destroyed during the Xishan period. The characteristics of this category of oil and gas pools are: 1) The traps were formed during the Xishan period and are unrelated to paleostructures; 2) They are distributed mostly in depressions and have poor matchups of generating, reservoiring, and capping conditions; 3) Their oil and gas is mainly secondary accumulations. Non-comatured poor-type oil and gas pools are the worst category in this article. The objective in classifying this category of oil and gas pools is to take into consideration the large number of new structures from the Xishan period in Turpan-Hami Basin and to draw attention to the fact that although there are many local structures in Turpan-Hami Basin, not all of them contain oil.

IV. Laws of Oil and Gas Accumulation

Here, we will integrate the general laws of oil and gas accumulation with the unique characteristics of oil and gas distribution in Turpan-Hami Basin to unify the general with the individual and establish an oil and gas distribution model for Turpan-Hami Basin.

1. The frequent alternation of oil reservoiring and generating strata and the non-homogeneity of oil reservoir strata determine the short migration distance of the oil and gas. At the same time, the restricted scope of the lake basin and the limited lake intrusion and expansion caused most of the excellent oil generating, reservoiring,

and capping combinations to be distributed along the margins of the primary subsidence region. It has now been determined that there are three primary oil generating depressions in Turpan-Hami Basin. They are the Yuergou-Toksun depression, Taibei-Qiudong depression, and Hami Sandaoling-Dananhu depression. The peripheries of these depressions are favorable locations for oil and gas accumulation. The distribution of the already discovered Shanshan, Qiuling, Wenjisang, Qiktim, Sinjinkou, and Yilahu oilfields conforms to this law (Figure 9 [not reproduced]).

2. Multi-strata system oil generation and multi-strata system oil reservoiring (Figure 1). Capping strata with a regionally stable distribution control the distribution of the primary generating, reservoiring, and capping combinations (Table 2 [not reproduced]). Existing data indicate that the primary generating, reservoiring, and capping combination in Turpan-Hami Basin has the Qiktim-Sanjianfang group mudstone as capping strata, Sanjianfang group sandstone as reservoir strata, and all oil generating strata below the Qiktim group as a source rock generating, reservoiring, and capping combination, as well as the mudstone of the upper of the Xishanyao group serving as capping strata with sandstone in the lower part serving as reservoir strata, and with the lower Jurassic system Badaowan group and Permian system serving as a source rock generating, reservoiring, and capping combination that controls the primary oil and gas accumulations in Turpan depression. Second comes the Triassic-Permian system generating, reservoiring, and capping combination which holds the primary position in Toksun depression in the Turpan depression and in Hami depression. In addition, the generating, reservoiring, and capping combination in which oil is generated and reservoired in the same rock in the Qiktim group, Badaowan group, and Permian system is also very important, and more discoveries will be made with more intensive exploration.

3. Paleostructures control the distribution of primary oil and gas accumulations. The paleostructures here mainly refer to structures that appeared in the middle and late Jurassic. It is quite obvious that this category of structures controlled the development of reservoir rock during the sedimentation stage, so they hold the advantage in the generating, reservoiring, and capping matchup and provide exceptionally advantageous conditions for the formation of oil and gas pools. The primary oil and gas accumulations in Turpan-Hami Basin were discovered in paleostructures, whereas new structures from the Xishan period had poor oil accumulation conditions.

4. Oil and gas accumulations were controlled by shear anticlines, strata erosion pinch-out zones, and lithologic pinch-out zones that developed on the background of paleouplifts, and they have compound oil and gas accumulation characteristics. In Turpan depression, the main oil and gas accumulation zones are shear anticline zones and thrust zones which caused the formation of compound bodies composed of shear anticline, fault-block, fault nose, lithologic, structural-lithologic, and other oil pool categories. Strata erosion unconformities are the primary aspect in Hami depression and caused the formation of strata unconformity, structural-stratigraphic, fault- lithologic, anticline, and fault-block oil and gas pools (Figure 10).

The main compound oil and gas accumulation zones in Turpan depression are at the western, southern, and eastern margins of the main Taibei depression and the northern and western flanks of Toksun depression, forming a recumbent X- shaped compound oil and gas accumulation zone (Figure 9). The main compound oil and gas accumulation zone in Hami depression is "a zone matched with a ring". "A zone" refers to the Sidaogou-Sanbao anticline zone which developed mainly anticline and structural-stratigraphic oil and gas pools. "A ring" refers to the oil and gas accumulation zone around the outer margin of Santongling-Dananhu depression which is mainly a strata erosion and pinch-out zone and lithologic pinch-out zone.

Shanshan-Qiuling anticline zone in Turpan depression is a compound oil and gas accumulation zone that is mainly shear anticlines, fault anticlines, and fault blocks. The shear anticlines and fault anticlines are the primary oil pool categories. Moreover, fault-block, fault-lithologic, fault nose, lithologic, and a variety of other

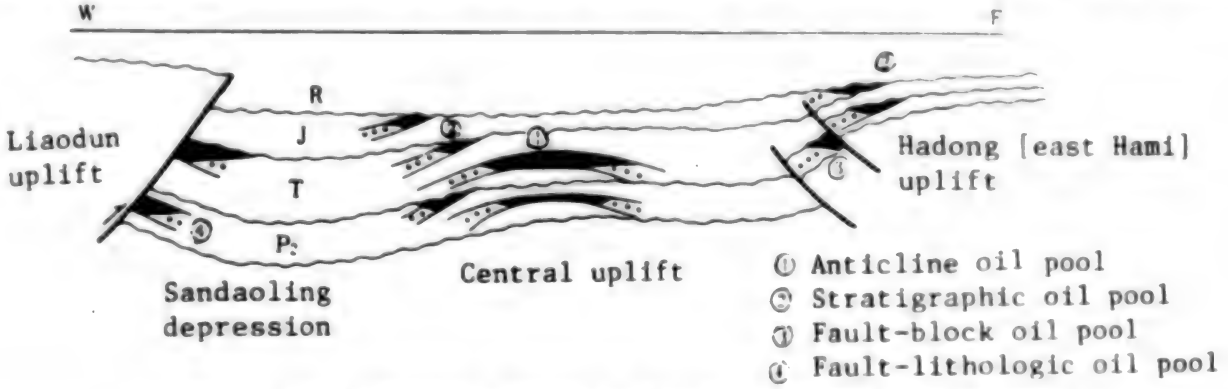

Figure 10. Hami Depression Compound Oil and Gas Accumulation Model Projection

types of oil and gas pools developed above, below, and at the flanks of the primary oil pools, forming a compound oil and gas accumulation zone.

V. Conclusions

1. In focusing on the unique characteristics of oil and gas accumulation in Turpan-Hami Basin, with a prerequisite of classifying oil and gas pools into structural type, stratigraphic-lithologic type, compound type, and other basic categories, each category of oil and gas pool can be further classified on the basis of the interrelationship of the period of trap formation to the period of oil and gas maturation and migration into comatured plentiful type, semi- comatured non-plentiful type, comatured but subsequently destroyed type, and non-comatured poor type oil and gas pools. This classification program helps increase the success rate in exploration.

2. The formation of plentiful type oil and gas pools benefitted from a favorable combination of the following geological conditions: 1) Traps formed earlier than oil and gas maturation and discharge; 2) Traps located in primary oil and gas discharge regions and near oil generation centers; 3) Transformation by late Xishan movement that strengthened the scale of structures without causing destruction; 4) Having excellent generating, reservoiring, and capping combinations, and good capping strata conditions; 5) Traps received oil and gas supplies during multiple periods.

3. The disadvantages of the non-plentiful charge of oil in non-plentiful type oil and gas pools are: 1) Traps were created after the period of large-scale discharge of oil and gas, so that after the traps had formed on a large scale, there was no oil and gas available for re-supply; 2) Trap locations are not good, so it was hard for them to receive continual supplies of oil and gas; 3) The generating, reservoiring, capping, trapping, and migration matchup conditions are rather poor.

4. Oil and gas pools are controlled by paleouplifts, paleoslopes, fault- anticline zones, and strata erosion pinch-out zones and have the characteristics of compound oil and gas accumulations. Turpan depression developed as a compound oil and gas accumulation zone dominated by stratigraphic oil and gas pools. On a planar view, they form a recumbent X- shaped favorable oil-bearing zone. Hami depression mainly has stratigraphic- lithologic and structural oil and gas pools along with some compound oil and gas accumulation zones. On a planar view, they form a zone matched with a ring. This conclusion helps in establishing different guiding ideologies for exploration and selecting appropriate oil exploration methods for the two depressions.

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Extent of Ordos Gas Find Being Tested

926B0061B Hohhot NEIMENGGU RIBAO in Chinese 27 Nov 91 p 1

[Article by Zhang Shuxin [1728 2579 0207]: "Prospecting For Natural Gas in Ordos Basin Shows Good Promise; steady Flow of Natural Gas From Five Ordos Wells"]

[Text] Dongsheng dispatch. The Eighth 5-Year Plan prospecting project undertaken by the North China Petroleum Geology Bureau of the Ministry of Geology—the Ordos natural gas prospecting project—has struck pay dirt for the first time. An 8 millimeter flow nipple trial brought in a steady gusher of 10,394 cubic meters of natural gas per day. This prospecting tract is located in the eastern section of the northern part of the Yishen declivity in the Ordos Basin covering an area of 5,000 square kilometers. Work done by the North China Petroleum Geology Bureau in recent years found this area to be a favorable site for a natural gas reservoir. This area's natural gas reserves are estimated at 2 trillion cubic meters.

Now five Ordos wells that the North China Petroleum Geology Bureau's Sanpu 5007 crew opened are in the process of enlarging the test results. The next step is to be testing of the well's main gas bearing formation. Both the abnormal value and the thickness of the gas formation have been found to be nine times and 3.3 times respectively that of the formation that has been tested. Prospects are even more considerable.

Fusion-Fission Hybrid Breeder and Its Role in Nuclear Power Development

926B0045B Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12 No 6, Dec 91 pp 12-17

[Article by Sheng Guangzhao [4141 0342 2507] and Huang Jinhua [7806 6930 5478] of the Nuclear Industry's Southwest Institute of Physics: "Fusion-Fission Hybrid Breeder and Its Role in Nuclear Power Development"; MS received 21 May 91]

[Text] **Abstract:** The principle and function of the fusion and fission-fusion hybrid reactor are briefly described. The hybrid breeder can provide sufficient fuel for a PWR or FBR. A system consisting of fusion-fission hybrid breeders and PWRs or FBRs is economically viable. The hybrid breeder will play a key role in solving the fission fuel shortage problem for large-scale development of nuclear power in China and maintaining the momentum in the development of pure fusion energy.

Key words: nuclear fusion, fusion-fission hybrid breeder.

I. Introduction

Heavy nuclear (U, Pu) fission reactions are the basis of nuclear power and other nuclear powered equipment to date. Since the first nuclear power plant was put into operation in 1954, there has been tremendous progress in the development and use of nuclear power. At present, nuclear power carries considerable weight in the electric power system in several developed countries. The construction of Qinshan and Daya Wan power plants is an important step for the nuclear power industry in China. Because of the limited availability of fission fuel and some inherent shortcomings of fusion reactors (such as highly radioactive fission products), as early as 1950 researchers began to explore the fusion of light nuclei (deuterium, tritium) as a clean energy source with an extremely abundant fuel supply. The development and application of fusion energy is a very difficult task—perhaps it is one of the most challenging topics encountered in the history of science. After 40 years of dedicated research, breakthroughs have been made in fusion research. The first milestone, i.e., a demonstration of scientific feasibility of fusion in the form of deuterium-tritium combustion, will be reached in the near future. However, the commercialization of fusion is still a long way off, probably by the middle of the next century. Hence, a system combining the mature fission reactor technology with fusion technology to create an advanced rector, i.e., fusion-fission hybrid breeder, is an effective means to solve the fission fuel shortage problem and to make use of fusion energy ahead of time.

II. Controlled Nuclear Fusion

A great deal of energy is released when light nuclei (such as the hydrogen isotopes deuterium and tritium) undergo fusion; this is fusion energy. The violent explosion of a hydrogen bomb is the uncontrolled release of this form of energy. If this energy can be released in a controlled manner for use by mankind, it will become an unlimited clean energy source to fundamentally solve the energy problem.

The primary reactions involved are:

$$D + D \begin{cases} \nearrow {}^3He + n + 3.27MeV, \\ \searrow T + P + 4.05MeV; \end{cases}$$

$$D + T \longrightarrow {}^4He + n + 17.58MeV;$$

$$D + {}^3He \longrightarrow {}^4He + P + 18.58MeV.$$

Due to the large reaction cross section, it is relatively easy to achieve fusion with deuterium and tritium. Hence, the development of fusion energy begins with the D-T reaction.

Fusion has the following attractive features:

(1) Deuterium, a fusion fuel, is naturally abundant. The deuterium-to-hydrogen ratio in seawater is 1:6500. The energy released by the fusion of deuterium contained in a liter of seawater is approximately equivalent to that released by burning 300 liters of gasoline. If all the deuterium in seawater is used in fusion, it is estimated that approximately 10^{17} MW-a of energy can be released. This is sufficient for mankind to go on for several hundred million years. Therefore, this type of fuel is essentially non-exhaustive.

(2) The fusion fuel tritium is a β isotope which has a 12.6-year half life and does not exist in nature. Nevertheless, it may be generated by a neutron-lithium reaction in the jacket of a fusion reactor. Hence, a D-T fusion reactor actually burns deuterium and lithium. Lithium is also abundant on earth. It is estimated to last at least several thousand years for D-T reactor use.

(3) The fusion product is helium, which is non-radioactive. This is unlike fission reactors, which inherently produce some strongly radioactive wastes.

(4) There is no danger of a nuclear explosion. To make a fusion reactor generate energy, the core plasma parameters (such as temperature, density and confinement interval) must satisfy certain conditions. Once these conditions are not met, the fusion reaction will self-terminate.

(5) High-energy neutrons generated by the D-T fusion reactor may induce structural materials to become radioactive. By proper selection or development of structural materials, it is projected that the fusion reactor is going to be far less radioactive than a fission reactor. Furthermore, these materials are solids which are easy to process and will not pollute the environment.

In order to obtain sufficient energy from fusion, the following three conditions must be met. (1) The fuel must be heated to an extremely high temperature. The minimum temperature (T) is approximately 100,000,000°C for D-T fusion and 500,000,000°C for D-D fusion. (At such high temperatures, matter is totally ionized, i.e., in a plasma state.) (2) The fuel must have a sufficiently high particle density (n) to be able to produce enough fusion energy. (3) The plasma energy confinement time (τ_E) must be long enough. Thus, this may be summed up as the need for the product of these three requirements $nT\tau_E$. As far as D-T fusion is concerned, $nT\tau_E \geq 2 \times 10^{21}$ m^{-3}-s-keV.

Such a high-temperature plasma cannot be confined in an ordinary vessel. Present fusion research is focused on two methods of confinement. One is inertial confinement fusion (ICF), which involves the use of a high-power laser or particle beam to rapidly heat up and compress a solid fuel to reach fusion conditions. Since the density is very high ($> 10^{22}$ cm^{-3}), the required confinement interval is relatively short (about 10^{-8} s). Because it is confined by the inertia of the fuel particle itself, it is called inertial confinement. Another method is magnetic confinement, i.e., the plasma fuel is confined by a magnetic field. In the area of magnetic confinement, the optimal plasma parameters are attained in a Tokamak. The Tokamak is close to break-even, i.e., $n(0)T_i(0)\tau_E = (8\text{-}9) \times 10^{20}$ m^{-3}-s-keV where n(0) and $T_i(0)$ are values on the magnetic axis and i represents ion. Despite this fact, pure-fusion commercial power plants still have a long way to go. The United States plans to finish the engineering of the ITER (international thermonuclear experimental reactor) by 1997 and complete its construction by 2005. A demonstration reactor will be designed by 2012 and constructed by 2025. The first commercial reactor will be designed by 2032 and built by 2040. This is an optimistic projection assuming smooth development and sufficient funding.

III. Fusion-Fission Hybrid Reactor

A fusion-fission reactor incorporates fission matter or convertible materials (e.g., ^{238}U, ^{232}Th) and some neutron doubling agents in a fusion reactor jacket in order to produce electricity and fission fuel by way of fission reactions induced by fusion-generated neutrons and to double the energy and neutrons through the (n, 2n) and capture reaction. A fusion-fission reactor that is primarily used to produce nuclear fuel is called a fusion-fission breeder.

The physical basis of a hybrid reactor is to use the fusion core as a neutron source. The neutrons are used for energy doubling, breeding fission fuel and tritium in the jacket. Every D-T fusion reaction generates a 14 MeV neutron and a total of 17.6 MeV of energy. The number of fusion neutrons per unit energy unit is four times higher than that of fission neutrons. Because one neutron is required to breed tritium, one fusion neutron alone is not enough. Therefore, it is necessary to double the number of fusion neutrons. Neutron doubling agents include ^{238}U, ^{232}Th, Be, ^{7}Li, etc. Fission materials are produced by way of the following reactions between neutrons and convertible materials:

$$n + {}^{238}U \longrightarrow {}^{239}U \xrightarrow[24\ min.]{\beta^-} {}^{239}Np \xrightarrow[2.4\ days]{\beta^-} {}^{239}Pu$$

$$n + {}^{232}Th \longrightarrow {}^{233}Th \xrightarrow[22\ min.]{\beta^-} {}^{233}Pa \xrightarrow[24.7\ days]{\beta^-} {}^{233}U$$

Just as ^{235}U, neutrons of any energy can cause ^{239}Pu and ^{233}U to undergo fission. Therefore, they can be used as fuels in light-water reactors.

Figure 1 shows two major fusion-fission reactors, i.e., fast fusion-fission hybrid reactor and suppressed fusion-fission hybrid reactor. In a fast fusion-fission hybrid reactor, the D-T fusion reactor core is surrounded by a jacket of convertible materials and lithium (^{238}U + Li, or ^{232}Th + Li, or ^{238}U + Li in front and ^{232}Th + Li in the rear). Fast fission of ^{238}U or ^{232}Th can be caused by fusion neutrons. At least one of the neutrons must react with lithium to produce tritium to replenish the tritium consumed in the core. The remaining three or so neutrons are used for breeding fission materials. In a suppressed fusion-fission hybrid reactor, the fusion core is surrounded by a jacket of tritium breeding material (Li) and non-fission neutron doubler (e.g., Be). Fusion neutrons are slowed down by this layer to below the fission threshold of the convertible material. One neutron is still needed to breed tritium and the remainder are used to produce fission fuels.

Because the fusion neutron power is amplified several fold in a hybrid reactor, the fusion core power can be lowered. Hence, the plasma confinement conditions are not as stringent as those for a pure fusion reactor. This is particularly true for a fast fission jacket. In order to evaluate the fusion requirements for a variety of hybrid reactors, two parameters are generally used, i.e., plasma power gain Q ($Q = P_f/P_{aux}$, where P_f is the fusion power and P_{aux} is the power input to sustain plasma temperature) and first-wall neutron load $(P_w)_n$ is defined as the fusion neutron power penetrating a unit area of the first wall. Usually, higher values of Q and $(P_w)_n$ indicate more rigorous physical and technical requirements. Table 1 lists the requirements for the two types of hybrid reactors and for a pure fusion reactor. In order to be able to produce nuclear fuel and electric power economically, Q must be high.

Table 1. Fusion Core Requirements for Hybrid Breeders

	Q	$(P_w)_n$, MW/m^2
Fast fission jacket hybrid	1-5	1-1.5
Suppressed fission jacket hybrid	6-15	2-3
Pure fusion reactor	Above 15	3-5

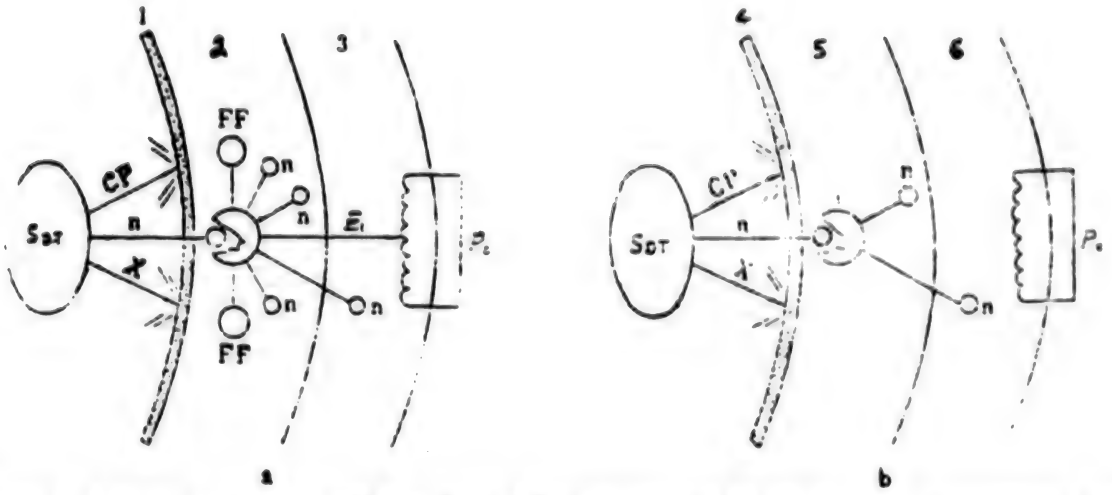

Figure 1. Schematic Diagrams of Fusion-Fission Hybrid Reactors. a—fast fission jacket, b—suppressed fission jacket

1, 4. First wall; 2. Convertible material (^{238}U and ^{232}Th), three neutrons for breeding fission fuels; 3. Lithium, one neutron used for breeding tritium; 5. Neutron doubling and tritium breeding layer, one neutron used for breeding tritium; 6. Convertible material layer, one neutron used for breeding fission fuel. S_{DT} represents the D-T fusion source, CP represents charged particle, FF represents fission fragment, E_t is thermal energy, P_e is electric power, and X represents X-ray.

The breeding ratio, F, is an important parameter representing the fuel production capability of a hybrid reactor. It is the net number of fission fuel nuclei produced by a fusion neutron. F varies as a function of the jacket design. From the jacket energy gain M and breeding ratio F, it is possible to estimate the fuel production capability of a hybrid reactor. Let us assume that the load factor is 0.7, then the amount of ^{239}Pu produced per year by each MW of thermal power is

$$N_{Pu} = 3.87\ F\ f(M)/M\ (kg/MW_{th}\text{-}a)$$

where $f(M) = 14.1M/(14.1M + 3.5^{\circ})$.

If M and F are known from the jacket design, then the annual fuel production capacity can be estimated accordingly. Usually, F and M are large for a fast fission reactor. If F = 1.5 and M = 10, then a 4,000 MW thermal power hybrid reactor (with a fusion power of 444.4 MW) can produce approximately 2,000 kg of ^{239}Pu per year. As for a suppressed fission jacket, F and M are lower because the number of fission incidents is fewer. If F = 0.75 and M = 1.6, then a 4,000 MW thermal power hybrid reactor (with a fusion power of 2,703 MW) can produce approximately 6,000 kg of ^{239}Pu per year.

Electric power systems using fusion-fission hybrid breeders to primarily produce nuclear fuels show very good promise because they can produce a great deal of fuel for many other fission reactors. Based on an estimate given in the literature, including direct, indirect and time-related investments, a fusion-fission hybrid breeder costs 2-3.4 times that of a light-water reactor of the same capacity. The analysis shows that when U_3O_8 costs \$55/kg, the ratio of electric power generating cost of a system with both hybrid and light-water reactors to that of using conventional light-water reactors alone is 1.05-1.11. This means that the power generating cost of the coexisting system is only 5-11 percent higher than that of conventional nuclear power. However, when the cost of U_3O_8 rises, the electricity generating cost of a conventional light-water reactor goes up while that of the hybrid reactor declines. When the cost of U_3O_8 goes up to \$200/kg, the power generating cost of the hybrid-light water reactor system is below that of conventional nuclear power.

In summary, a hybrid reactor has the following advantages. It does not need fission fuel. The breeding fission materials are potent. The power density of the fission jacket of the hybrid reactor is only 1/10-1/100 that of a fission reactor. In a hybrid breeder-light water reactor system, fuel and power are generated separately. The hybrid breeder is primarily used to produce fuel and most of the energy is generated by light-water reactors supported by the hybrid breeder. From the standpoint of fusion energy, it is a bridge between available energy source today and pure fusion energy in the future.

IV. Role of Hybrid Breeder in Nuclear Power Development in China

Based on our energy demand, large-scale development of nuclear power is required in the first half of the 21st Century. For example, the installed capacity should reach over 120 GW by 2050. This will be more than 10 percent of the total capacity (the 1989 worldwide

average was 17 percent). As we know, the first-generation nuclear power plant was based on military reactor technology. It was not very fuel efficient. Large-scale use of commercial nuclear power must make full use of ^{238}U and ^{232}Th. Since nuclear fuel is not abundant in China, there is a greater urgency to develop second-generation nuclear power plants. As a breeder, the fast neutron hybrid breeder technology is more mature and should be given priority. Nevertheless, it is unrealistic to depend on fast breeders alone to achieve large-scale nuclear power by 2050. Even at a high breeding ratio of 1.58 and a 1-year processing time outside the reactor, fuel must be put into a fast breeder in the first 3 years of operation. Under the constraint of our nuclear fuel supply, if everything moves along smoothly, the total installed capacity is estimated to be 90 GW by 2050. If a high breeding ratio is not compatible with other factors such as economy and safety, the actual value will be far below the ideal value. Then, the scale discussed above must be further discounted. A hybrid reactor can produce 10 times more fuel per year than a fast reactor of the same size. Compared to a fission reactor, (1) the hybrid reactor releases less energy in each fusion reaction. Hence, fusion neutrons are produced at a higher rate at identical thermal power. (2) More than two neutrons are produced in each fission reaction in a fast reactor and one is consumed to sustain the chain reaction. This is not required in a hybrid reactor. Therefore, it has a higher breeding ratio. Hybrid breeders can completely alleviate the constraints on the scale of nuclear power development due to fuel availability.

As for the pure fusion reactor, based on an optimistic projection, it will be commercialized in 2040-2050 in developed countries. In addition to technical hurdles, making the pure fusion reactor economically attractive is an important task in fusion research. The high cost of a fusion reactor is caused by the difficulty for the first wall to sustain a very high neutron flux. This leads to a low engineering power density of 1 MW/m^3, as defined by "total thermal power/volume of fusion reactor structural material." The fusion power plant designed today costs twice as much as a fission power plant. Even this has a great deal of uncertainty. Apparently a commercial pure-fusion power plant is still a long way down the road. It is of great significance to develop intermediate applications to maintain the momentum of fusion research. A hybrid breeder may be able to play such a role. As mentioned before, it is economically attractive to use a hybrid breeder to produce fuel as well as to generate electricity. The core plasma requirement for a hybrid breeder can vary. As the quality of core plasma is upgraded, the nuclear fuel-producing capability also improves. At the present level of fusion development, a series of key technical issues, such as heating and confinement of plasma, confinement of alpha particles, development of materials (especially the first wall and high thermal load parts), remote maintenance technology, tritium technology and post-treatment of fuel, must be solved for a hybrid breeder. If we are serious about it and devote our effort to it, these problems can be addressed and overcome in 20-30 years.

In conclusion, a hybrid breeder may play a pivotal role in our nuclear power development in the first half of the next century. It will supply the fuel necessary for the large-scale development of nuclear power. In addition, it will push fusion research forward toward the development of third-generation nuclear power plants to fundamentally solve the energy problem for mankind.

V. Design Concept for Hybrid Breeder

Since the early 1980's, we have more or less completely finished the conceptual design of the magnetic mirror hybrid breeder (CHB),[1] Tokamak Engineering Test Breeder (TETB),[2,3] and Tokamak Commercial Breeder (TCB).[4] Table 2 shows the major parameters for the TETB and TCB.

Table 2. Major Parameters for TETB and TCB

	TETB	TCB
Plasma large radius R, m	4.0	6.40
Plasma small radius a, m	1.0	2.00
Fusion power P_f, MW	200.0	2,000.0
Plasma power gain Q	10	37
Neutron wall load $(P_w)_n$, MW/m^2	0.63	1.86
Mean jacket energy gain M	4.0	2.8
Breeding ratio F	0.54	0.7
Tritium breeding ratio T	1.06	1.06
Maximum thermal power P_{th}, MW		5,740
Mean thermal power P_{th}, MW	680	4,176
Net electric power output P_e, MW		1,000
Annual ^{239}Pu production M_p, kg	100	4,300

The core fusion power of the TETB is 200 MW, plasma energy gain Q is 10, and neutron wall load $(P_w)_n$ is 0.63 MW/m^2. Liquid lithium is used as a coolant, as well as a tritium breeding agent, in the jacket. The neutron doubler is beryllium. The thermal power of the jacket is 680 MW. If the operating factor is 0.35, this reactor is capable of producing approximately 100 kg of ^{239}Pu per year.

The core fusion power of the TCB is 2,000 MW, plasma energy gain Q is 37, and neutron wall load $(P_w)_n$ is 1.86 MW/m^2. Liquid lithium is used as a coolant, as well as a tritium breeding agent, in the jacket. The neutron doubler is beryllium. The mean thermal power of the jacket is 4,176 MW and the net electric power output is 1,000 MW. This reactor is capable of producing over 4,000 kg of ^{239}Pu per year.

VI. Conclusion

In recent years, a great deal of progress has been made in fusion research. Plasma conditions equivalent to Q_{DT} = 0.7 have been achieved. Combustion experiments using

D-T plasma are expected to take place on a new generation of Tokamak facilities (e.g., JET, TFTR) in the near future to demonstrate the feasibility of fusion and to investigate the behavior of combustible plasma. In addition, ignition experiments and engineering pilot reactors are also being actively planned. After 5 years of operation, the China HL-1, which was designed and constructed in China, has produced very good experimental results. This has laid a solid foundation for the construction of larger devices as well as for the study of plasma characteristics. Since 1986, the hybrid breeder was included in the high-technology development plan. In the past 5 years, encouraging results have been obtained in the conceptual design of the hybrid breeder and related engineering experiments. As long as we can commit our resources to advanced fusion research, it is entirely possible to complete an engineering hybrid breeder by early next century and construct commercial hybrid breeders by 2030 to supply sufficient fuel for nuclear power.

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Strategic Position of the FBR in China's Nuclear Power Development

926B0045A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12 No 6, Dec 91 pp 7-11

[Article by Ma Dayuan [7456 1129 0954] and Yi Xiaoyi [2496 1420 3015] of the China Institute of Atomic Energy: "Strategic Position of the FBR in China's Nuclear Power Development"; MS received 4 Aug 90]

[Text] **Abstract:** Based on the forecast for energy and electricity demand up to the middle of the next century (2050), the strategic position of the fast breeder reactor (FBR) in nuclear power development is analyzed.

Key words: nuclear power, development strategy, fast breeder reactor.

I. Introduction

The uranium utilization rate of a thermal neutron reactor is very low (1-2 percent). If we only develop thermal neutron reactors, then nuclear power will eventually be limited by the amount of uranium we can economically obtain. An FBR can breed fissile materials to improve the utilization rate to 60-70 percent. After thermal neutron reactors are developed to some stage, the timely introduction of FBR can provide a thrust to nuclear power development to ensure the long-term steady growth of nuclear power. This is a common issue encountered in the long-range planning of nuclear power for every nation.

China's nuclear power industry is in its infancy. The pressurized water reactor (PWR) is the first generation reactor for nuclear power. Issues such as when to bring in an FBR, how fast and on what scale, and what the effect on nuclear power development will be, must be analyzed based on specific situations in China. Major factors involved include: our demand for nuclear power, long-term supply of uranium and our country's economic status. The discussion in this paper is limited to nuclear fuel recycling. It will serve as a reference for more detailed analysis.

II. China's Demand for Nuclear Power Development

1. Forecast of Energy Resources and Power Requirements

Our energy demand and growth rate of energy consumption depend on many factors. The most important include the rate of population increase, changes in industrial structure and effectiveness of energy conservation measures adopted (progress in science and technology). Table 1 shows several forecasts of the overall energy demand to 2050. I is an estimate of the overall energy needs based on an analysis by different sectors such as industry, agriculture, transportation, services and civilian use.[1] II is derived from macroscopic analysis of population growth, mean national product per capita and product to energy consumption ratio.[2]

Table 1. Estimates of Total Energy Demand to 2050 (100 million tons of standard coal)

Year		1980	1985	2000	2010	2015	2030	2050
I	Fast	6	7.3	14	—	20	31	55
	Slow	6	7.3	13	—	18	26	49
II		6	7.3	12.1	15.3	—	24.4	36.9

In 1985, 401.7 billion kWh of electric power was generated in China, which is 16 percent of the total energy consumed. By the end of this century, the Ministry of Water Conservancy and Electric Power estimated in its plan that the total power generating capacity will be 240 GW by 2000. Electric power will be 26-27 percent of the overall power demand. In 1980-1985, the ratio of electric power to total energy demand in developed nations was approximately 40 percent. As our economy grows, the weight of electric power will increase. Table 2 shows a forecast of our electric power development.

Table 2. Forecast of Electric Power Development by 2050

Year	2000	2015	2030	2050
Total energy demand (100 million tons of standard coal)	13.5	20	31	50
Weight percent of electric power, %	29	33	30	40
Installed capacity, GW	240	421	769	1,436

2. Analysis of Nuclear Power Development

Based on reliable data, approximately 15-21 billion tons of petroleum products can be ultimately obtained. As of now, 4.1 billion tons have been positively surveyed. Based on the ultimate upper limit, production can increase gradually from the present rate of over 100 million tons per year until it peaks in 2030 (approximately 300 million tons per year). It then tapers back down to the present level by 2050. The ultimate natural gas reserves in China are approximately 16.5×10^{12} m^3. They will grow at a faster rate after 2020, peaking out in 2050 (approximately 150 billion m^3 per annum). In 2050, the annual production of natural gas will be equivalent to 41.3 billion tons of standard coal. This is only 8.6 percent of the total energy demand. Our hydropower resources are expected to be almost fully developed by 2030. Total installed capacity is approximately 263 GW which can generate 920.5 billion kWh of electricity per year; this is merely 14 percent of the electricity demand in 2050. Hence, it will be difficult to alter the basic situation in which coal is the major source of energy and electricity in China. Coal is abundant in China. Reserves total 796.2 billion tons. However, they are not evenly distributed. Approximately 62.4 percent (479.8 billion tons) is concentrated in Shanxi, Shaanxi and Inner Mongolia. With the exception that Xinjiang, Gansu, Ningxia, Qinghai and the southwest are self-sufficient, other regions must have coal shipped in. Especially in economically developed regions along the coast in eastern, northern and southern China, shipping has become a limiting factor due to the vast quantity and long distance involved. A coal-intensive energy structure aggravates air pollution and accelerates the greenhouse effect. It has an adverse impact on the ecology. This is another factor to be taken into consideration.

In conclusion, with existing technology, the best decision is to develop nuclear power which is cheap and clean. To have nuclear power carry substantial weight in our future energy load is the only way to alter our energy structure and alleviate the energy shortage.

Nuclear power has just begun in China. The first phase of the Qinshan power plant (300 MW) and the Daya Wan power plant in Guangdong (2 x 900 MW) are expected to be completed in the near future. Preliminary work on Phase 2 of the Qinshan power plant (4 x 600 MW) has also begun. According to the nuclear power development plan prepared by the Ministry of Energy Resources, 6,000 MW of nuclear power installed capacity will be ready by 2000. It will represent 2.6 percent of the total electric power installed capacity. By 2015, the total nuclear power installed capacity will rise to 30,000 MW, which represents 6 percent of the total capacity. Assuming nuclear power will represent 10-20 percent of the total capacity by 2050, the low and high rate nuclear power development curves as a function of year will be as shown in Figure 1. In order to meet this kind of demand for nuclear power, we should develop more fuel-efficient reactors, especially the fast breeder reactor.

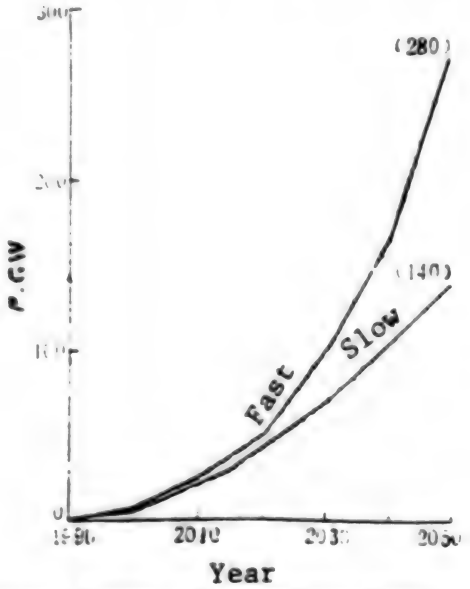

Figure 1. Forecast of Nuclear Power Development

III. Position and Role of FBR in Future Electric Utilities

1. Limitation of PWR

Thermal neutron reactors—including the pressurized water reactor (PWR), advanced pressurized water rector and high-temperature gas-cooled U-Pu cycle reactor—usually have a very low uranium utilization rate and consume a great deal of natural uranium. Corresponding to the calculated forecast of low and high rate development of nuclear power, the amount of the uranium required is shown in Figure 2. Table 3 shows the fuel utilization characteristics of PWR.

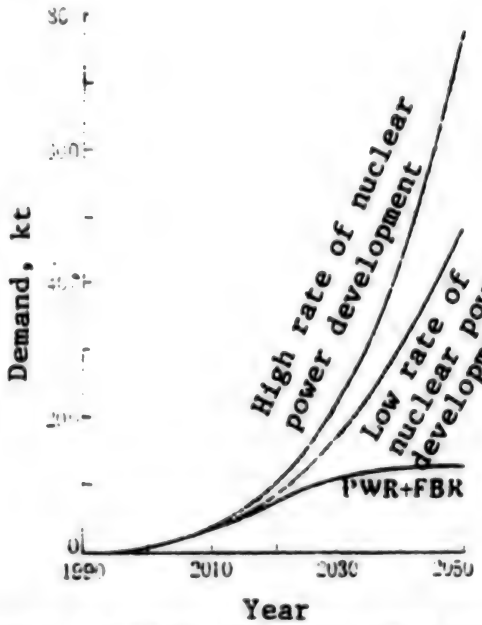

Figure 2. Cumulative Demand for Natural Uranium (PWR alone)

Table 3. Fuel Utilization Characteristics of PWR*

Consumption of unloaded fuel, MW-d/t		33,000
Conversion ratio		0.6
Initial load, t/GW	U-235	1.8
	Heavy metal	79.7
Balanced annual replacement, t/GW-a	U-235	0.804
	Heavy metal	25.1
Balanced annual removal, t/GW-a	U-235	0.216
	Fissile Pu	0.163
	Heavy metal	24.3
Lifetime (30 years) uranium demand, t/GW		4,162

*Load factor is 0.75.

It should be pointed out that the results shown in Figure 2 and Table 3 do not include the fuel required for existing power plants. Based on the fact that uranium is limited to 120,000 or 150,000 tons, PWR plants cannot be built after 2011 and 2014 if nuclear power development proceeds at the higher rate, or 2014 and 2017 if it follows the lower rate. The corresponding capacities are 28 and 36 GW, respectively (see Table 4).

Table 4. Limitation of Nuclear Power Development (PWR alone)

Natural uranium	Year PWR construction ceases		Nuclear power capacity limit, GW
	Low rate	High rate	
120,000 tons	2014	2011	28
150,000 tons	2017	2014	36

It will require a total of 583,000-1,166,000 tons of natural uranium to meet the nuclear power target of 140-280 GW in 2050. This is approximately 7-14 times the current reserve. It requires a reserve increase by an average of 12,000 tons per year, which is almost impossible.

2. Prospect of Nuclear Power Development With a Combination of PWR and FBR

(1) Fuel Utilization Characteristics of Commercial FBR

The FBR is still in a commercial demonstration stage. There is plenty of room for improvement in the commercial demonstration plant (SPX-1) that is in operation, and there is always some ongoing research and development. In particular, there has been a breakthrough in the development of a novel metal fuel (U-Pu-Zr), which may be commercialized in the near future. Therefore, the analysis is focused on both the mature oxide fuel and the novel metal fuel.

We have a serious energy shortage which requires the sustained growth of nuclear power at a faster pace. Hence, it is an objective need to bring in the FBR. The data in reference 3, as shown in Table 5, is used as the basis of this analysis.

Table 5. Fuel Utilization Characteristics of a Commercial (1 GW) FBR Power Plant*

Fuel type	Hybrid oxide fuel		Metal fuel (U-Pu-Zr)	
Fuel stay in reactor, a	2	2	2	2
Fuel stay outside reactor, a	2	1	2	1
Specific fuel (Pu) at core, kg/GW	3,158	3,158	2,488	2,488
Specific fuel (Pu) in system, kg/GW	6,315	4,736	4,977	3,732
Annual replacement (Pu), kg/GW-a	1,579	1,579	1,244	1,244
Annual removal (Pu), kg/GW-a	1,824	1,831	1,656	1,660
Breeding ratio	1.325	1.325	1.582	1.582
System doubling time, a	25.8	18.8	12.1	9.0

*Load factor is 0.75.

(2) Combined Development of PWR-FBR

Following the lower rate forecast and based on the 125,000-ton limit of natural uranium, the annual demand and cumulative demand for uranium, accumulation of plutonium based on the PWR development model, and the separation power requirement will be as shown in Table 6.

Table 6. PWR model, Pu Accumulation, Demand for Natural U and Separation Power

Year	PWR power, GW	U demand cumulative, kt	U demand annual, kt/a	Accumulated Pu, t	Annual separation power, kt/a
2000	6.0	7.2	1.36	3.25	0.92
2005	14.0	17.4	2.44	9.88	1.74
2010	22.0	30.7	3.46	22.59	2.55
2015	30.0	52.5	3.92	41.83	3.05
2020	30.0	71.6	3.81	66.02	3.04
2025	27.0	89.3	3.39	89.88	2.73
2030	24.0	105.1	3.01	111.39	2.43
2035	16.0	116.8	1.93	129.49	1.61
2040	8.0	123.4	0.91	141.22	0.80
2045	0	124.9	0	146.44	0
2050	0	124.9	0	146.44	0

From the standpoint of developing nuclear power to the largest extent possible, the optimal model for using the FBR is to finish fuel (Pu) preparation and technology preparation at the same time. This means that the scale of FBR development is totally determined by the amount of Pu accumulated and by the performance of FBR and is not limited by the degree of technical preparation. Obviously, this is an ideal case. Figure 3 [not reproduced] shows the calculated scale of nuclear development in 2050 based on this assumption.

As can be seen, the breeding difference of oxide fuel and metal fuel has a significant impact on the scale of nuclear power achievable in 2050. Reducing the stay of fuel outside the reactor is very important. Considering the fact that the research and development period is relatively long between now and the point where the FBR can be commercialized on a large scale, the introduction of FBR power plants might be further delayed due to lack of technical preparation or other reasons, and power plant performance might have to be lowered somewhat. The mixed oxide fuel cannot meet minimum targets set for nuclear power development in 2050. It is appropriate to choose the metal-fueled FBR as the direction of development.

In reality, the most probable case is that the commercialization of the FBR will not be determined by the preparation of Pu. Instead, its introduction will be delayed due to lack of technical preparation. Table 7 shows the effect of introducing the metal-fueled FBR in 2015, 2020, 2025 and 2030 and the effect of fuel stay outside the reactor for 1 and 2 years on the scale of nuclear power development. The calculation assumes that the rate of introduction is 1 GW in year 1, 2 GW in year 3, 4 GW in year 5,....., until reaching the limit of plutonium supply. From Table 7, we can see the significance of bringing the FBR on line as early as possible.

Table 7. Effect of FBR Delay on Nuclear Power Development in 2050 (GW)

Year of FBR on-line	Stay outside reactor, a	
	2	1
2015	225	621
2020	201	376
2025	123	260
2030	96	170

IV. Conclusions

(1) Our energy and electricity supply is very tight. It is difficult to change our long-term energy structure which is centered around coal. Coal-burning power plants are generating very serious transportation and pollution problems. In order to alleviate this dilemma and alter the energy structure, we must develop alternative energy sources as early as possible. To date, nuclear power is the most reliable, economical, clean and advanced alternative.

(2) Based on the availability of uranium in China, thermal nuclear power plants alone account for a very small proportion, far below the long-range demand for nuclear power.

(3) If the FBR is developed as early as possible based on our development of thermal nuclear power, with a supply of approximately 120,000 tons of natural uranium, our nuclear power output may reach 140 GW by 2050. This is 10 percent of the total electric power requirement. Nuclear power can play a meaningful role

in altering our energy structure. Particularly for coastal developed ares where the demand for electricity is high and energy resources are poor, nuclear power is of even greater significance.

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CRACBJ Model Description

926B0070A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 13 No 1, Feb 92 pp 38-42

[Article by Shi Zhongqi [2457 0112 7871] of the Institute of Nuclear Energy Technology of Qinghua University: "CRACBJ Model Description"; MS received 5 Jan 91, revised 25 Jul 91]

[Text] **Abstract**: CRACBJ is a risk assessment program for the Guangdong Nuclear Power Plant. It is written based on the CRAC2 program. This paper discusses the purpose of the modifications made, major contents of modifications and its adaptability to the plant site. In addition, it also presents the VAX versions of CRACBJ and CRAC2.

Key words: nuclear accident, consequence analysis, probabilistic safety assessment, atmospheric dispersion.

I. Introduction

The CRACBJ program, which is used for consequence and risk analysis (i.e., accident consequence assessment, or ACA) to meet the Guangdong Nuclear Power Plant Probabilistic Safety Assessment (GNPSA) requirements, is a modification of the U.S. CRAC2[1] program. There are no changes to the basic structure of CRAC2. With the exception of a few items to suit the GNPSA output, the input format is also virtually untouched. The unedited CRAC2 program is the 1984 revision for the CDC mainframe computer. The mode and operation of CRAC2 are discussed in detail in references 1 and 2.

The purposes of modifying CRAC2 are as follows: (1) to include the geographic and climatic characteristics of the site—in addition to replacing the permanent weather file, major modifications were made to the source code; (2) to absorb technical progress made in the field of ACA since CRAC2 was released to reflect several internationally accepted emergency response principles (since emergency response can critically impact consequences and risks); and (3) to match the source output of GNPSA.

II. Explanations Associated With CRACBJ

1. Atmospheric Dispersion Parameters

Atmospheric turbulence has two sources, i.e., mechanical and thermal. The topography of the site is one of the principal mechanical factors causing turbulence. Atmospheric dispersion parameter σ_y and σ_z are closely dependent upon the ground roughness Z_o.

Daya Wan (Daya Bay), the plant site, has a complicated topography. On the north, there are hills on the Dapeng peninsula. There is a 700-m-high mountain 3 miles to the north. The land portion of the plant site has the characteristics of rolling hills. The CRAC2 program, however, uses the atmospheric dispersion coefficient for a typical nuclear plant site in the United States. Although a rough correction has been made to the standard P-G dispersion parameters (from Z_o = 3 cm to Z_o = 10 cm), the question of whether it is appropriate for Daya Wan yet to be answered.

Since no atmospheric dispersion experiment has been done at the plant site, no directly applicable parameters are available. Two major conclusions can be drawn from related data:

(1) Based on the weather data gathered at Dakeng,[3] the site of Suzhou Thermal Plant, the ground roughness is of the order of meters, which is far greater than the Z_o used in CRAC2.

(2) According to the wind tunnel experiment done in France over a 5 km radius around Daya Wan, under neutral weather conditions and with a 68.5-m smoke stack, the ground concentration is 2-4 times higher than that calculated by a conventional program.[4]

Although it is not possible to directly obtain the atmospheric dispersion parameters at Daya Wan from the data discussed above, the type of parameters that should be used in the ACA program can be determined based on the actual topography of the site and the data given in those two studies.

In addition to field test and wind tunnel experiment, there are three other methods we can use to handle highly rough hilly terrain in meteorology.

(1) Shift atmospheric stability (as defined by the Pasquill method) toward the direction of instability, such as that specified in the State Environmental Protection Bureau's Domestic Standard GB3840-83, pertaining to the requirements for σ_y and σ_z for a hilly terrain.

(2) Use atmospheric dispersion parameters measured in a highly rough terrain. The IAEA[5] and our National Nuclear Safety Administration's Guideline HAF0103 recommend the use of a set of parameters measured in Germany.[6]

(3) Treat roughness as a variable in calculating atmospheric parameters. Different parameters[7] are chosen for different Z_o.

Considering the fact that no ground roughness has been accurately determined at Daya Wan, based on the topography of the site and the available data, we employed method 2 for the sake of convenience. The CRAC2 source code was modified using a set of dispersion parameters (see Table 1) measured at a medium to high roughness (Z_o = 1 m). When using the CRACBJ program (with dispersion parameters corresponding to Z_o = 1 m) in GNPSA, the risk of acute death within a radius of 0.5 km around the reactor is 50 percent higher than that with Z_o = 0.1 m (which is the original value in CRAC2). Since the selection of such parameters is not experimentally verified, the parameters used in CRAC2 are still used for comparison in risk analysis.

Table 1. Dispersion Parameters Associated With Medium to High Ground Roughness*[5,6]

	Atmospheric stability type					
	A	B	C	D	E	F
P_y	0.87	0.87	0.72	0.62	1.69	5.38
Q_y	0.81	0.81	0.78	0.77	0.62	0.58
P_z	0.22	0.22	0.21	0.20	0.16	0.40
Q_z	0.97	0.97	0.94	0.94	0.81	0.62

* $\sigma_{y(x)} = P_y X^{Q_y}$, $\sigma_{z(x)} = P_z X^{Q_z}$, X is the distance from the source (m).

2. Parameters in the Lift Equation

In a serious accident involving core meltdown or safety containment failure, the leakage of radioactive matter is often accompanied by the release of a large amount of heat. Thus, it causes the release height to rise. The lift of hot smoke and steam is directly related to the surrounding atmosphere. The CRAC2 program assumes that the temperature is 6°C. This might be because stable weather conditions (type E and F) usually occur at night. Daya Wan is located in southern China, where the temperature is higher. The average nighttime temperature in 1985 was 21.3°C. In CRACBJ, stability parameters calculated based on the temperature at Daya Wan are used to replace the corresponding values in CRAC2. This change of temperature makes the lift height corresponding to type E and F weather decline by approximately 20 and 10 percent, respectively. In the event of a short-term discharge, when the discharge height is 80 m, the maximum ground concentrations under weather condition E and F are 80 and 40 percent higher, respectively, than those with a 100-m discharge height (based on P-G dispersion parameters).

3. Wash Factor

The fraction of nuclei removed by wet precipitation, f_w, is calculated using the following formulas:

$$f_w = 1 - \exp(-\Lambda t_i)$$

$$\Lambda = cR$$

where Λ is the wash factor in units of s^{-1}, R is the rainfall in units of mm/h, and c is a constant in units of h/mm-s.

In CRAC2, the constant c is dependent upon atmospheric stability. Based on more recent research, c is independent of stability and is usually chosen to be 1×10^{-4} h/mm-s.[8]

4. Emergency Response

(1) Evacuation Plan for Residents

In the CRAC2 emergency response model, one can choose between two plans for early-stage evacuation of personnel after a leak. One is to evacuate within a certain period after the radiation fallout hits the ground. The other is to evacuate 7 days after the radiation fallout reaches the ground. If the 7-day bone marrow dosage exceeds 2 Gy (200 rem), then evacuation takes place within 24 hours. CRACBJ modifies the irradiated organ and dose standards specified by CRAC2 based on the emergency evacuation and relocation intervention levels recommended by IAEA.[9] When the overall dose due to external radiation in 7 days exceeds 0.5 Gy (50 rem), evacuation must take place in 24 hours. 0.5 Gy is the upper intervention limit for evacuation (and relocation). When the overall dose is greater than 0.5 Gy, evacuation is mandatory.

(2) Maximum Ground Decontamination Factor

CRAC2 takes long-term ground radiation into account. If such long-term dose exceeds the specified limit, the model determines whether ground decontamination is necessary in order to lower it to an acceptable level. The CRAC2 source code uses 20 as the maximum decontamination factor. After taking the Chernobyl accident into consideration,[10] it was modified to 10 in CRACBJ. In CRACUK, a British ACA program, it is chosen to be 3. This change will increase the area of land that will be permanently banned for any use after an accident in order to reduce the long-term collective dose.

5. Input and Output

(1) Input Changes

In the original CRAC2 source code input, 54 isotopes are divided into eight groups. In CRACBJ, they are divided into 10 groups based on the 2nd-level output source

terms of GNPSA. Ba and Ce are removed from the Sr and La groups, respectively, to improve the accuracy of computation.

(2) Output Changes

CRAC2 divides the area within an 800-km radius surrounding the power plant into 16 sectors and 34 rings. Since even in the event of a very serious accident, the consequences outside an 80-km radius are considered to be minimal, and furthermore, to be consistent with the population distribution around the plant, GNPSA only assess consequences within an 80-km radius. This area is divided into 16 sectors and 13 rings. Hence, it was necessary to modify the source code to change the spacing accordingly.

The original output provides the number of people that receive more than a 2 Gy (200 rem) bone-marrow dose. This was also modified. Other than modifying the source code, changes are also necessary in the input.

6. Permanent Data Files

(1) Weather Data File

CRACBJ provides a weather data file for Dayawan based on the observation made at the Dakeng site, including wind direction, wind-speed atmospheric stability and rainfall as a function of time, as well as seasonal mean mixing layer heights.

(2) Dose Conversion Factor File

Based on new dose conversion data,[11] we wrote a new dose conversion factor file TAPE21. However, in view of the fact that most new factors are smaller than their original values and the new factors are not complete yet, the original TAPE21 file is still used in GNPSA.

7. Suitability of Atmospheric Dispersion Model in CRACBJ

In CRACBJ, other than the fact that the actual site has been taken into consideration in the weather file, atmospheric dispersion parameters and stability parameters, there are two more issues associated with the suitability of the atmospheric dispersion model: i.e., the linear model and the fact that the coastal characteristics of the site have not been taken into account.

(1) Comparison of Linear Model and Trajectory Model

CRACBJ uses a linear atmospheric dispersion model which is similar to that in most PSA programs. In computing such weather sequence, only the wind speed change in the first hour is considered. It does not take into account any wind direction change during the discharge and dispersion period. Rigorously speaking, the linear model is only applicable in ideal atmospheric condition with a homogeneous and stable turbulent flow field. In some recently developed ACA programs, a trajectory model is used for atmospheric dispersion. The change of wind direction is taken into consideration to calculate the time and space dependence of smoke. The trajectory model obviously is more consistent with the real weather situation, especially in the complicated terrain at the plant site. Hence, it is necessary to analyze the difference between the two models in post-accident assessment. The trajectory model has two major factors affecting the consequence. One is that because wind direction change is considered, the concentration of radioactive material disperses over an even larger area, leading to a smaller peak compared to that of the straight line Gaussian model. The entire polluted area will increase. Next, because the smoke is curved, it takes longer to reach a distance away from the plant compared to the straight line model. This makes radiation precipitate over a larger range of area and increases the probability of evacuation. Studies show that the trajectory model predicts 25 percent less early-stage fatalities compared to the straight-line model. However, the number of people needing to be evacuated is 30 percent higher. The area contaminated with a 1 mSv/a 50-year cumulative dosage will also increase significantly.[12] On the average, the 20-km total contamination area will double. The number of delayed random deaths will also increase by 100 percent. This is because the number of people that need late-stage protection (e.g., decontamination, banning from eating and drinking contaminated food and water) is decreased due to exposure to a lower-than-specified dose limit.[13] Besides, the trajectory model needs more computing time. The study done by J. A. Jones et al. shows that the CPU time will increase by a factor of 10.[12] After considering various factors, their conclusion is that the straight-line model is still suitable for most PSA applications.[12]

(2) Effect of the Coastline

Dayawan is located by the sea. The effect of the land-sea interface on atmospheric dispersion has been described by several models. A study on the effect of the seacoast on the consequence[14] shows that, in a short range, the seacoast alters the concentration distribution, especially the concentration distribution surrounding the most concentrated point on land. However, on a larger scale, there is little difference between an inland site and a coastal site as far as projected concentration is concerned. Hence, it is rational to conclude that the coastline has no significant impact on atmospheric dispersion within the context of PSA.[14]

III. VAX Versions of CRACBJ and CRAC2

CRACBJ and CRAC2 have been ported to the VAX minicomputer. The VAX versions provide many cities and organizations without a CDC mainframe computer with a tool for estimating accident consequences. From the results obtained with standard examples and the ACA applications in Guangdong, both CDC and VAX versions of CRACBJ and CRAC2 are reliable.

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Developing the 'Fifth Energy Resource'

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[Article by Huang Shaoping [7806 4801 1627] and He Xiangmei [6320 7449 2734]: "Development of 'The Fifth Energy Source'"]

[Text] Everyone in the world is profoundly aware that energy conservation is "the fifth energy source" after the four main energy sources: petroleum, coal, water energy, and nuclear energy. In 1986, the International Energy Organization published a comprehensive report summarizing major accomplishments in the conservation of energy by the 19 major developed countries in the world during the 12-year period 1973-1985. Their principal conclusion was that structural methods for conserving energy can be realized through progress in technology, i.e., a change from high energy consumption to low energy consumption industry. This road enables these countries to get through energy crises smoothly, and it gives powerful impetus to their development side-by-side of technology and experience.

During the 1980's China's energy industry scored remarkable achievements under guidance of a policy of "adhering to equal emphasis on development and conservation," becoming the third largest country in the world in energy production and use. Nevertheless, China is still a long way from meeting energy needs for economic development and the people's daily lives.

Energy Situation Exceedingly Serious

1. Energy Reserves "Abundant in the Aggregate, Insufficient in Per Capita Terms, and Unevenly Distributed"

Eighty percent of China's coal is concentrated in north China and in the "three wests" area [meaning, presumably, the northwest, west, and southwest], which means that coal from the west must be shipped to the east, and coal from the north must be shipped to the south. Today, 40 percent of the nation's transportation is used to haul coal. Seventy percent of the country's water energy resources are concentrated in the southwest, necessitating the delivery of electric power from the west to the east.

Although China has plentiful energy overall, because of its large population, energy resources are in fairly short supply, mineral energy (coal, petroleum, and natural gas) amounting to only one-half the world, one-seventh the USSR, and one-fourth the United States per capita amount. Petroleum resources are in even shorter supply, per capita reserves amounting to only one-ninth the per capita amount of world reserves. China's per capita consumption of energy is very low at approximately 840 kilograms of standard coal per year, which is only one-third the world average. In 1989, China's per capita consumption of electricity was 500 kWh per year; in industrially developed countries it was 10,000 kWh per year.

2. Conflict Between Energy Supply and Demand

Experts estimate that China has had an annual 50 billion kW electric power shortage, a 30 million ton coal shortage, and a 10 million ton petroleum shortage for some time. Due to the energy shortage, approximately 30 percent of the country's industrial production capacity has gone to waste. The energy shortage, particularly the electric power shortage, has meant a sustained electricity shortage nationwide for 20 years. The sudden energy shortage of a structural nature that occurred in June 1988 posed a serious threat to the entire country's socioeconomic development. Forty percent of the country's industrial production capacity lay idle because of the shortages of energy and of raw and processed materials. This caused a loss of 400 billion yuan in output value and 50 billion yuan in profits and taxes for the year. Since the last half of 1989, the country's energy situation has changed somewhat. Coal is no longer in as short supply as formerly, the amount on hand rising; and electricity supply problems have eased in some areas. Nevertheless, these are temporary situations resulting from a slump in national economic development and insufficient work for quite a few industrial enterprises. The country's energy shortage situation has not changed fundamentally.

The last 10 years of this decade are a crucial 10 years for attaining the first step strategic goals in China's modernization. Intensive basic industries such as agriculture and energy, as well as communications and transportation will be substantially developed; the people's standard of living will reach a comfortably well-off level, and energy supplies will greatly increase. "The 10-Year Plan and the Eighth 5-Year Plan Programs for National Economic and Social Development" that the Fourth Meeting of the Seventh NPC passed provide for an energy output in 1995 equivalent to 1.17 billion tons of standard coal for an annual 2.4 percent increase; an energy output in 2000 equivalent to nearly 1.4 billion tons of standard coal, for an annual 2.7 percent increase, and an annual 6 percent growth in GNP. Clearly, the speed of increase in energy production is lower than the speed of national economic growth. Calculations based on the current high level of consumption show that by 2000 an energy supply equivalent to 1.74 billion tons of standard coal will be needed.

3. Challenges That the Energy Situation Is Facing From Environmental Problems

Coal constitutes 76 percent of China's energy consumption, 2.7 times the average world level. This energy structure in which coal is paramount is facing challenges from environmental problems. The overly large percentage of coal consumed not only creates transportation shortages, but the large amount of direct use of coal also produces low energy utilization efficiency that causes serious environmental pollution. Reportedly, soot from

the burning of coal in China accounts for 73 percent of all effluent, for 90 percent of the sulfur dioxide, for 85 percent of carbon dioxide, and for more than 50 percent of nitrogen oxide. In addition, in China's rural villages where energy consists mostly of biomass, 75 percent of which is firewood and plant stalks and stems, approximately 300 million tons (actual amount) of firewood is burned each year. This is nearly three times a rational amount of firewood gathering, and it damages the ecological balance.

4. Energy Development Limited by Many Factors

The development of energy today is limited not only by what the country's financial resources, material resources, and technological level can bear, but also by serious population, resources, transportation, and environmental restraints. For example, the amount of investment required in China to get the same 1 kW of electric power is between 2,000 and 3,000 yuan for thermal power, 4,000 yuan for hydropower, 8,500 yuan for nuclear power, and between 25,000 and 40,000 yuan for solar power. By contrast, an investment of only between 300 and 900 yuan is required to conserve the same 1 kW of electric power.

To summarize the foregoing, the conservation of energy is a major problem in development of the country's national economy and society. China must implement an energy-conserving development strategy.

Enormous Energy Conservation Potential

Statistics are frequently dry, yet they illuminate problems.

Even though China scored very great accomplishments in energy conservation during the 1980's, the problems of a low energy utilization rate, high energy consumption per unit of product, and poor economic returns have not changed fundamentally. By comparison with advanced countries, the gap is very large. This also shows the existence of an enormous energy conservation potential in China.

1. Macroeconomic Returns Poor From Energy Use

Statistics for 1988 from the World Resource's Institute in Washington and London on 10 major economic powers (not including the USSR) show China highest in energy consumption for GNP figured in United States dollar units, five times that of France and Japan, 3.4 times that of the UK, three times that of Brazil, and 1.6 times that of India.

Pursuit of speedy growth in output value over a fairly long period of time at the expense of energy conservation in the building of China's economy has resulted in a very high energy investment coefficient. For every 10,000 yuan of GNP in 1990, the energy equivalent of 9.3 tons of standard coal was consumed. Even though this was 30 percent lower than the 13.36 tons of standard coal consumed in 1980, it was still rather high.

2. High Consumption Per Unit of Product

Even though energy consumption per unit of product declined for nearly two-thirds of more than 60 different major products surveyed during the 1980's, energy consumption per unit of major products produced in China today remains very high. The waste of energy is serious. For example, energy consumption per ton of steel produced in China's main steel concerns was 30 percent higher than for major steel producing countries during the early 1980's.

3. Low Energy Utilization Rate

Relevant data show an energy utilization rate for China of only 32 percent, which is approximately 18 percentage points lower than for developed countries. This means a potential for saving the equivalent of more than 300 million tons of standard coal exists today in total energy consumption, which is calculated to be 1 billion tons of standard coal. (Figured at projected total consumption in 2000, the energy conservation potential is equivalent to approximately half a billion tons of standard coal.) Even by increasing the energy utilization rate 1 percentage point, 30 million tons of standard coal could be conserved.

The foregoing analysis shows a very great potential for energy conservation in China. This potential may be found largely in thermal energy power plants, electricity transmission, and machines that consume petroleum, as well as in energy used in production and in daily life. In the electrical industry alone (power generation, power transmission and transforming, and industries that use electricity), China loses more than 10 percent of its electric power in transmission and transforming. (In Japan, the percentage has fallen to 6.) Figured on the basis of the transmission of 600 billion kW of electricity in 1990, the annual loss of electricity in the transmission and transforming process was 60 billion kW. Attainment of the level of Japan would mean the annual conservation of 24 billion kW. Electric boilers are large industrial consumers of electricity. Statistics show the consumption of approximately 30 billion kW of electricity by all kinds of electric boilers nationwide. This is approximately 7 percent of the total amount of electricity generated nationwide in recent years. With technological transformation, efficiency could be greatly increased. Experts estimate the potential for electricity conservation in the country's electrical industry at more than 80 billion kW.

Development of the fifth energy resource—energy conservation—requires little investment, shows quick results, has a short capital turnover time, and produces high returns. Therefore, "adherence to equal emphasis on development and conservation," and a policy of energy conservation is absolutely no expedient measure, but a long-range national development strategy.

The energy conservation potential is very great, but can China's technological level support the heavy burden of

energy conservation? Do we have the gumption to reach the energy conservation goals of the 1990's? Yes, we do!

Technological Means of Conserving Energy

Experts feel that for the near-term, China's energy conservation technology should stress the following main aspects of the problem:

1. Increase the heat energy utilization rate. The emphasis should be on improving the heat efficiency rate of the nation's industrial boilers and industrial kilns and furnaces, which consume 65 percent of the nation's energy, developing joint production of heat and electricity, centralizing the supply of heat, and improving efficiency of the heat supplying systems.

2. Increase the electric energy utilization rate. The emphasis here should be on the following: Increasing the operating efficiency of systems in which machinery and electrical appliances such as blowers, water pumps, and electric motors are used; developing electric energy saving technology, particularly electric power and electronic energy saving technology; and saving electricity by technological equipment that consumes high amounts of electricity to produce products such as electric steel, ferroalloys, electrolytic aluminum, calcium carbide, caustic soda, synthetic ammonia, ethylene, yellow phosphorous, and cement.

3. Vigorous spread to application of new technologies, new techniques, new equipment, and new materials. Examples include continuous casting, rich oxygen injection, ionic membrane sodium hydroxide production, synthetic ammonia self-supplied steam ("converting two coals into a single coal"), cement decomposition ex-kiln, and cement block manufacture.

4. Increase in coal cleaning and processing, and the percentage of such coal used in electric power generation.

5. Multiple uses of resources. Multiple use of low thermal value fuels, recovery for use of waste heat, waste energy, ashes, and sediments; better recovery and use of discarded materials.

6. Replacement of antiquated transportation equipment with low energy consuming, highly efficient transportation equipment. Examples include the use of electric and internal combustion locomotives in place of steam locomotives, and use of diesel vehicles in place of gasoline vehicles.

7. Using petroleum instead of coal. Reduced burning of oil in power station boilers and kilns, and reduced use of oil available to oil fields, oil refineries, and petrochemical plants. Development of coal gasification, liquification, coal slurry processes, and clean coal technologies in an effort to find the best economics of technology methods to replace premium sources of energy.

8. Development of kinds of coal for use in the daily life of the people in cities and towns, developing coal gas for use in some large and medium size cities where conditions permit. In northeast China, north China, and northwest China, every effort should be made to provide heat from central installations.

9. Improve the use of energy in the daily life of rural people. The principles of "suiting general methods to specific circumstances, the complementary use of many different kinds of energy, multiple use of energy, and emphasis on results" should be followed in the vigorous spread of firewood-conserving and coal-saving stoves, energetic firewood forest afforestation, active and steady development of methane gas, and accelerated building of small hydropower facilities. Development for use of renewable energy technology, improving the energy self-sufficiency rate by promoting a benign cycle in energy.

10. Better energy-saving construction. Emphasis should be placed on improving the composition of walls, on heat ventilation, on heat supply control, and on temperature control.

11. More study of soft science and technology. Development of applied systems engineering techniques and computer techniques to the scientific management of resources conservation and multiple use of resources, information exchange, and energy conservation forecasting and planning.

To summarize the foregoing, development of the fifth energy resource is not only extremely necessary, but also both technologically and economically feasible. It is hoped that national government agencies will make sure that energy conservation work will be done when drawing up policies.

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Influence of Haline and Thermal Stages in Convection on Vertical Hydroacoustic Structure of Upper Layer of Waters in Tropical Atlantic

927N0094A Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 3, May-Jun 92 (manuscript received 29 Jun 90) pp 59-65

[Article by N. P. Bulgakov and P. D. Lomakin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.463.21]

[Abstract] The temporal change in the vertical hydroacoustic structure of surface tropical water masses in the Atlantic Ocean under the influence of convective mixing conforms to definite regularities, among which are the following. Convection is accompanied by the formation and disappearance of acoustic waveguides and also jump layers with positive and negative speed of sound gradients and monotonic and nonmonotonic changes in the velocity of propagation of elastic oscillations with time. It is possible to define the characteristics of transformation of the $C(z)$ profile of three variants of thermohaline structures with a high positive vertical velocity gradient which differ with respect to the sign on the vertical temperature gradient. The haline stage in convective mixing in freshened surface waters with a negative temperature gradient forms a speed of sound jump layer with a negative gradient and a subsurface sound microwaveguide. These structural elements do not arise in haline convection in waters with a zero temperature gradient. In freshened waters with a positive vertical temperature gradient at the beginning of operation of saline convection a speed of sound jump layer with a positive vertical gradient is formed. In the defined variants of thermohaline structures the haline stage of convective mixing causes changes in the speed of sound profile nonmonotonic with time, weakening and total disappearance of a haline near-surface sound channel which is formed in the rainy season. Thermal convection causes a qualitatively similar form of the $C(z)$ profile in freshened waters. In the course of development of thermal convection the speed of sound in the convective layer decreases monotonically with time. The near-surface sound channel is intensified. A speed of sound jump layer with a great positive gradient is formed. The thermal stage in convective mixing in highly saline tropical waters with an upper quasihomogeneous layer results in the appearance of a subsurface interlayer with a great positive speed of sound gradient, a clearly expressed subsurface sound channel and a monotonic decrease in the velocity of propagation of elastic oscillations with time. Figures 4; references 7: 6 Russian, 1 Western.

Measurements of Sea Surface Roughness Parameters With Transition From Calm to Wind Waves

927N0098B Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 4, Apr 92 (manuscript received 3 Jun 91) pp 424-431

[Article by G. N. Khristoforov, A. S. Zapevalov and M. V. Babiy, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.326]

[Abstract] The results of research on the variability of the parameters of a two-dimensional probability distribution of the slopes of sea wind waves under different hydrometeorological conditions, measured using a laser slope meter from an oceanographic platform erected in the Black Sea, are given. The operating principle of the slope meter was similar to that of the slope meters described by C. S. Palm, et al. and V. A. Hughes, et al. It measures the slope vector of a small (about 2 mm^2) sea surface area. The range of slope measurements was +/- 80°, the error was 0.2°, readings were made each 0.02 s and wave heights were up to 1.0-1.1 m. It was found that in situations when there are sticks there are the sharpest changes in the statistical parameters (dispersions of slopes and other third- and fourth-order coefficients). With higher wind speeds, from 4 to 11 m/s, the parameters of the probability distributions are close to those obtained earlier in the studies of Cox and Munk, except for the anisotropy coefficient, which gradually decreases from 2 to 1.5. Figures 2; references 8: 3 Russian, 5 Western.

Resonance Interaction Between Surface and Internal Waves

927N0098C Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 4, Apr 92 (manuscript received 5 Jun 91) pp 439-443

[Article by S. Ya. Vlasenko, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.31]

[Abstract] Despite the great interest in the interaction between surface and internal waves in the ocean, the literature usually examines only the mechanism of modulation of the field of surface waves under the influence of a stipulated field of internal waves. However, no allowance has been made for self-consistent changes in the structure of surface and internal waves caused by their nonlinear interaction. One of the few studies taking into account the nonlinear interactions between short surface and long internal waves in a two-layer ocean was made by V. V. Petrov (IZV. AN SSSR. FAO, Vol 15, No 7, pp 740-749, 1979), who derived a system of equations which made possible a detailed analysis of the interaction of surface and internal waves and a determination of the parameters and increments of decay and modulation instabilities observable in the interaction process, but it has since been shown that this system is nonintegrable and methods making it possible to construct precise solutions of the Cauchy problem are inapplicable to it. With this taken into account, it is shown that in the neighborhood of resonance, characterized by a coincidence of the phase velocity of an internal wave and the group velocity of a packet of surface waves, the system of Petrov equations can be transformed into a system of Zakharov equations describing long-short wave resonance such as is characteristic for physical processes having dispersion relations with double or multiple branches. Proceeding on this basis, it is shown that the existence of stable and self-consistent wave systems is

possible in the neighborhood of resonance of surface and internal waves. Reference 6: 4 Russian, 2 Western.

Wind Role in Variability of Energy of Inertial Oscillations in Black Sea Surface Layer

927N0098D Moscow IZVESTIYA AKADEMII NAUK SSSR. FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 4, Apr 92 (manuscript received 4 Jul 91) pp 442-446

[Article by Yu. N. Golubev and A. Yu. Kuftarkov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.3]

[Abstract] It is now well established that inertial movements in the upper layers of the ocean have a predominantly wind origin, but it is unclear why their amplitude so frequently experiences almost harmonic variations with a period substantially exceeding the period of inertial oscillations. A study was made to cast additional light on the mechanism operative in this situation without pretense at an exhaustive exploration of the problem. The study was based on measurements of current velocities made in March 1988 during the 49th cruise of the Mikhail Lomonosov at five buoy stations southwest of the Crimean Peninsula with the current meters positioned at the horizons 10 and 30 m. There were strong inertial oscillations of velocity whose amplitude changed substantially with time, clearly wind-induced. Wind data made it possible to construct the required spectra, an energy peak was registered corresponding to a period of 15.3 hours. Using such data the simple problem of generation of inertial oscillations in the Ekman layer by a wind periodic in time is examined. The results are compared with the findings of other authors. It is shown, for example, that the mechanism described by L. M. Fomin in IZV. AN SSSR: FAO, Vol 9, No 1, pp 37-39, 1973, does not fit the particular observational data considered. Figures 3, references 12: 6 Russian, 6 Western.

Discrimination of Long-Period Component of Water Temperature Variations in North Atlantic

927N0100A Moscow OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 23 Jul 90, after revision 21 Dec 90) pp 219-227

[Article by Yu. P. Krasovskiy and S. I. Kazakov, Experimental Division, Marine Hydrophysics Institute, Yalta; UDC 551.463.6]

[Abstract] The slowly changing component of multiyear variations of ocean water temperature is determined by a long-period asymptotic form of these variations obtained using thermohydrodynamic equations. Such an asymptotic form contains some number of parameters which are evaluated on the basis of observational data. The resulting dependence has a general character, applies for any moment in time and is related to the used observations only with respect to the accuracy of the evaluated parameters. The asymptotic form used is described and its application to an analysis of multiyear temperature variations for different regions of the ocean is illustrated. The data presented on year-to-year ocean temperature variations show that the constructed long-period asymptotic form can be regarded as the trend in multiyear variations of this temperature. The small number of characteristics of the air pressure field over the ocean, determining this trend, indicates a considerable synchronism in variations of the slowly changing component of water temperature in different regions of the ocean. Such a synchronism appears to be characteristic of other regions of the world ocean, not only the North Atlantic. It is desirable that this trend be used in an analysis of climatic variations because it reflects the universality of such variations for different regions of the ocean. Figures 5, references 9: 8 Russian, 1 Western.

Stratification of Waters in Western Black Sea

927N0100B Moscow OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 4 Sep 90, after revision 26 Mar 91) pp 234-240

[Article by O. R. Andrianova and A. V. Kholoptsev, Marine Hydrophysics Institute, Odessa; UDC 551.465.41:551.463.24]

[Abstract] On the basis of an analysis of more than 20 hydrological surveys (from 1978 to 1989) it was possible to establish the presence of a convergence zone along the continental slope of the Black Sea, into which flow the Dnepr, Southern Bug, Dnestr and Danube, consisting of a chain of anticyclonic eddies. The use of acoustic methods for investigating the structure of these waters, as well as the hydrological characteristics, made possible a more detailed tracing of the paths of propagation and transformation of freshened shelf waters forming in the northwestern part of the Black Sea and also a more precise determination of the characteristics of their seasonal variability. An intensification of anticyclonic activity in this region in May-June was demonstrated. This is attributable to the high waters on rivers in this season of the year. The mechanism of replenishment of the energy of anticyclonic eddies by cold freshened shelf waters is discussed. The cited results indicate that the use of acoustic methods for investigation of hydrological processes in the sea broadens the possibilities of detailed analysis of the nature of transformation of freshened waters and in the future can be used widely in oceanology. Figures 3, references: 8 Russian.

Computation of Wavenumber-Frequency Spectrum of Noise From Distant Shipping

927N0090A Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 14 Feb 91, after revision 8 Aug 91) pp 223-228

[Article by O. N. Anisimova, Morfizpribor Central Scientific Research Institute; UDC 534.834.1]

[Abstract] A method is proposed for determining shipping noise as the total noise of ships in those areas where the probability of detection of a single ship is less than a stipulated level. In such cases the considered noise generation area is dependent on the hydroacoustic conditions for sound propagation and the critical signal-to-noise ratio at the detector. The case of a flat-bottomed sea is examined and a number of other assumptions are made. If the densities of shipping for all types of ships and the wavenumber-frequency spectrum of fields near ships of each type are known it is possible to compute the mean wavenumber-frequency spectrum of the field of distant shipping using the detector antenna and to estimate the limits of change of this random function. For this purpose it is first necessary for each type of ship to determine the zones in which the probability of ship detection is less than the stipulated level. Then a newly derived formula is used in computing the mathematical expectations of the wavenumber-frequency spectra of the fields for each zone and for all types of ships and by adding them, determine the full mean level of the wavenumber-frequency spectrum of the field. Formulas are proposed for computing the variance, making it possible to determine the total variance of each term of the wavenumber-frequency spectrum and to find the total variance as the sum of the variances of these terms. Figure 1, references: 5 Russian.

Sound Scattering by Sphere With Allowance for Energy Absorption

92UN0090B Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 16 Apr 91) pp 252-259

[Article by V. A. Bulanov and L. Bjorno, Problems in Marine Technologies Institute, Far Eastern Department, Russian Academy of Sciences, Danish Technical University; UDC 534.24]

[Abstract] In J. ACOUST. SOC. AMER., Vol 74, No 5, pp 1542-1554, 1983 W. H. Lin, et al. examined sound scattering and absorption on a solid sphere and cylinder with allowance for the thermoviscous mechanism, but the derived system of equations was only solved numerically and no analytic evaluations of the effect were made. In order to fill this gap the scattering of a plane monochromatic acoustic wave by a sphere was examined with allowance for the absorption of energy caused by the thermal mechanism. This energy absorption mechanism is similar to that which is observed with the reflection of waves from plane surfaces (Konstantinov effect). The energy absorption attributable to thermal conductivity is substantial for sound scattering at high frequencies and also for soft objects and for bodies with fixed properties close to the properties of a fluid. It was found that the resonance lines in the scattering function, extremely narrow and great in amplitude, observed in the case of allowance only for radiation losses, with allowance for the indicated energy dissipation mechanism become broader and lesser in amplitude. Some resonance lines in this case disappear with adequately high kR (S_n,kR is the sound scattering function) and sound frequency values. Figure 1, references: 19: 5 Russian, 14 Western.

Geoacoustic Noise of Fast-Moving Craft on Reservoir

92UN0090C Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 30 Jul 90, after revision 19 Apr 91) pp 371-373

[Article by S. V. Merkushin and A. B. Shemyakin, Acoustics Institute imeni N. N. Andreyev, Russian Academy of Sciences; UDC 534.6:550.34]

[Abstract] A study was made of the geoacoustic noise of a fast-moving craft moving across a reservoir using onshore seismic detectors. The noise of hydrofoils of the "Meteor" and "Raketa" types was investigated. Reception of geoacoustic waves was with the standard three-component "Cherepakha-M" seismic detector (three mutually orthogonal velocimeters—two horizontal and one vertical) mounted on the shore and embedded 0.5 m at a distance 200 m from the axis of craft's course. The axis of maximal response of one of the horizontal detectors was oriented parallel to the craft's course. The spectral fast analysis of the geoacoustic noise with an SK4-72 spectrum analyzer with repeated passage of hydrofoils near the detector indicated that characteristic discrete components appear in the frequency ranges 65-75, 130-150 Hz and above. A more detailed spectral analysis of the records of geoelectric noise was with a Buell and Kjer two-channel signal analyzer in the frequency range 50-100 Hz. Using the known speed of hydrofoil movement and Doppler shift of 70-Hz discrete components it is possible to estimate the velocity of propagation of geoacoustic waves. The geoacoustic oscillations generated by such a craft constitute surface waves propagating with a mean velocity 395 m/s with a frequency of the oscillations about 70 Hz. Figure 1, references: 4: 2 Russian, 2 Western.

Spatial-Temporal Structure of Ocean-Atmosphere Thermal Interaction in North Atlantic

92UN0093A Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 92 (manuscript received 6 May 91) pp 98-102

[Article by S. B. Zavertyayev and M. I. Maslovskiy, Leningrad Hydrometeorological Institute; UDC 551.465.71(261.1)]

[Abstract] An analysis was made of the spectra of an 18-year time series of the mean monthly anomalies of ocean surface temperature, air temperature, flows of apparent heat, latent heat and virtual heat for five-degree regions of the Atlantic Ocean from 10 to 60°N. A polycyclic nature of variations of processes of thermal interaction between the ocean and the atmosphere and the spatial distribution of their principal energy-bearing periods was demonstrated. A tendency to a decrease in the period of water and air temperature variations with

an increase in latitude is traced. The instability of the period of annual variation of the thermal state of the two media near the interface caused by oceanic circulation and manifested in dynamically active regions of the ocean forms most of the temperature cycles in the range 8-16 months. The spatial and temporal structures of water and air temperature are similar and differ from the reciprocally similar heat flow structures. More than half the time series of temperatures and less than a third of the heat flow series have strong periodic variations from three to 54 months. Approximately a third of the water and air temperature series are characterized by a coincidence of energy-bearing periods and about 40 percent of the heat flow series also have coinciding variations. Identical cycles of temperatures and flows are observed in individual cases. The intensity of low-frequency heat flow fluctuations greatly changes in dependence on the region and the low frequency variability of temperatures everywhere bears a considerable part of the energy. Figure 1; references 11: 8 Russian, 3 Western.

Diffraction of Surface Gravity Waves on Underwater Obstacle

917N0001K Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 2, Feb 92 (manuscript received 13 Feb 91) pp 204-208

[Article by I. S. Dolina and Ye. N. Pelinovskiy, Applied Physics Institute, Russian Academy of Sciences; UDK 551.466.8]

[Abstract] An approximate method was used in solving the problem of diffraction of a surface gravity wave on an obstacle situated at the bottom of a fluid. In an earlier article (DOKL. AN SSSR, Vol 295 No 5, pp 1058-1060, 1987) the authors proposed an approximate method for computing the field of scattered waves and a comparison was made with the results of numerical computations for the case of scattering of a surface wave on a sphere in an infinitely deep fluid. The accuracy of the method in that case was quite high. However, it is clear that, in the case of a fluid of finite depth the situation may substantially change and in the limiting case of shallow water the sole characteristic scale is the size of the object, which may be large. Accordingly, the problem was solved of the scattering of a surface wave on an underwater obstacle in the case of an arbitrary fluid depth. The dependence of the reflection coefficient on fluid depth, length and angle of arrival of an incident wave was investigated. A separate study was made of the shallow water approximation and in this case there is a numerical solution of the problem and a comparison of the results made it possible to evaluate the accuracy of the derived formulas. It is shown in a number of commonly observed cases of scattering of a wave on obstacles that the proposed method can be used on a practical basis. Figures 4; references 7: 5 Russian, 2 Western.

Possibility of Retrieving Geoacoustic Parameters of Sea Floor Using Experimental Data on Green's Function of Hydroacoustic Waveguide in Broad Frequency Band

917N0001L Moscow IZVESTIYA RUSSIAN ACADEMY OF SCIENCES. Physics Vol 55 No 7, Jul 91 (manuscript received 7 Mar 91) pp 1436-1441

[Article by I. V. Lisichkin and A. B. Rozenfeld, General Physics Institute, USSR Academy of Sciences; UDK 534.231]

[Abstract] An algorithm is given for retrieving acoustic signal and sea floor parameters by employing the results of wide-band sounding using signals with extrapolic modulation. A numerical analysis procedure is proposed which rests on the one hand on the theory of perturbations for the eigenvalues and eigenfunctions of a plane-layered waveguide and on the other hand on a numerical method for solving an overdetermined system of linear algebraic equations. The proposed inverse method has definite advantages in comparison with those previously in use. The experimental method is quite simple, requiring only a wide-band emitter and a single hydrophone. An experiment can be carried out on a quasi-Markovian path with a store of less reliable values for determining coordinates. Simple data processing with a fast Fourier transform algorithm, obtaining of a great volume of data during a short time interval and with evaluation of information on both field amplitude and phase. The Green's function carries the greatest possible amount of information and with an adequately broad frequency band is a most fundamental source of information than a modal spectrum or the arrival times of a signal in individual modes or along individual rays. References 12: 9 Russian, 3 Western.

Generation of Internal Waves by Barotropic Tide in Region of Oceanic Ridge

917N0001A Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 92 (manuscript received 27 May 91) pp 3-7

[Article by S. V. Dovgaya and L. V. Cherkesov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDK 532.593]

[Abstract] Within the framework of the linear theory of long waves, with allowance for the operation of Coriolis force, a study was made of the generation of internal waves by a barotropic tide in a two-layer ocean of variable depth in which a barotropic wave is incident at an arbitrary angle on the axis of an extended ridge whose elevation changes continuously. The examined basin is unbounded in horizontal directions and is filled with a two-layer fluid. In this formulation, a variant of formulations published earlier, the dependence of the amplitudes of the internal waves on the angle of incidence of the barotropic tide and the geometry of the bottom rise are investigated. The analysis indicates that reflected and transmitted internal waves are propagated almost normal

to the ridge, that is, the direction of their propagation is almost not dependent on the direction of inflow of the barrier jet side. However, the amplitudes of the generated internal waves are significantly dependent on the angle of inflow of the barotropic tide. These maximum values are attained in the neighborhood of the critical angles. 5 figures, 2 references: 1 Russian, 1 Western.

Experimental Research on Hydrophysical Characteristics and Dynamics of Waters in Northwestern Black Sea in Zone of Main Black Sea Current

92UMOPA Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 2, Sep/Oct 91 (manuscript received 1 Jul 90, after revision 4 Aug 90) pp 45-56

[Article by V. A. Blinkov, V. A. Dubov, and O. V. Shulgin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol] [UDC 551.465.62]

[Abstract] The results of one of the stages of experimental work in a test range lying on the continental slope of the northwestern shelf and the adjacent abyssal part of the Black Sea are presented. This is a region of interaction of waters forming on the northwestern part of the shelf and main Black Sea waters. The research was carried out from the Professor Kolesnikov research ship operating in a test range located to the southwest of the Crimea. The structure of current, distribution of zones of subsidence and upwelling and location of mesoscale fronts are discussed. The experimental work, implemented in August 1988, indicated that in the test range within the frontal zone of the Main Black Sea Current there are several mesoscale fronts (antidebitumen) persons with a convergent nature of circulation. A possible reason for the formation and evolution of these fronts is the outflow of northwesterly waters onto the principal Black Sea waters. In the work area there is an alternation of positive and negative divergence. In August the salinity and temperature fields are spatially well matched, zones where the isolines of these characteristics are close together have a similar configuration and are close geographically. The principal elements of the current field in August are flow from the northeast, undergoing transition into westerly along 43°30'N, and southwesterly. Instrumental measurements of currents do not make it possible to regard the Main Black Sea Current as a stable, clearly expressed jet. In the test range there are flows, sometimes with different directions, with a horizontal extent of several tens of kilometers. Figures 5, references: 6 Russian.

One Method for Retrieving Speed of Sound Profile in Acoustic Sounding of Ocean

92UMOPA Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 37 No 5, Sep/Oct 91 (manuscript received 1 Sep 88, after revision 16 Apr 91) pp 886-892

[Article by S. V. Bureniuev and Yu. V. Dudkin, Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences] [UDC 534.222]

[Abstract] Although many methods for determining the speed of sound in the ocean have been proposed which are of theoretical importance, their practical application to environmental retrieval of the speed of sound profile is doubtful because: 1) the real ocean as the scales characteristic for locating problems (fractions of a meter - units of meters) has little in common with a plane-layered model; 2) for the characteristic speed of sound gradients and the reflection coefficient is above 10^{-3} and even with ensure operation at the cavitation threshold the level of the reflected signal is much below the ocean noise level. The idea of the proposed method for determining the speed of sound is as follows: the reflection from fluctuations of hydrophysical parameters (more importantly, temperature) is used in retrieving the dependence of their mean values on depth, making use of the fact that the statistical and averaged hydrophysical characteristics are interrelated to one another in a definite way following from the physical essence of the processes transpiring in the water layer. The connecting link between the mean characteristics and their fluctuations is the turbulence of water masses because small-scale fine features of hydrological parameters are caused by the mixing of water in the presence of gradients of their mean values. Formulas are derived which express the essence of the proposed method for restoring the speed of sound profile. Experiments for checking it were carried out in the waters of the Pacific or the North Pacific in regions with typically northern and typically southern hydrologies at depths. Data refer to during the daytime when the depth of the sound-scattering layer of biological origin was maximal. The observation procedure, calculations and processing are discussed in detail and illustrated on an example. Figures 3, references: 11 Russian.

Resonant Amplification of Longwave Disturbances on the Northwest Shelf of the Black Sea

92UMOPA Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 320 No 2, Sep 91 (manuscript received 13 Feb 91) pp 476-480

[Article by N. Yu. Voitsinger, Yu. K. Dymnyy, and B. A. Kagan, Leningrad Branch of the Shirshov Institute of Oceanology, USSR Academy of Sciences] [UDC 551.465.55(1-4)]

[Abstract] In recent years there has been a drastic worsening of the ecological condition of the Black Sea. In the worst case, coastal regions have sluggish circulation and poor mixing when there are continuous agricultural discharges into the sea. Efforts to improve water quality should use reliable local hydrodynamic models that allow one to calculate and analyze in detail the structural laws governing coastal regions in order to solve diagnostic, planning, and optimization problems. This article states and numerically solves the problem of defining the spectrum of natural oscillations of the Black Sea in a two-layer approximation. Analysis reveals the location of natural oscillations on the spectrum as well as the possibility of resonant amplification of harmonics with periods of 16.57 and 27.31 hours, similar to the

periods of the periods observed on the flooding of the northwest shelf in February 1976. In order to consider the shallow water dynamics of the northwest shelf one must correctly describe important details of the geometry of the coastal region. This article does not use the typical approach, in that it uses curvilinear coordinates. The initial equations look like Euler's equations. This approach may be compared with other approaches using Euler's equations. Figures 2; references 3: 2 Russian 1 American

Allowance for Atmospheric Parameters in Laser Remote Gas Analysis

[illegible]

(Arkhangelsk V. N. Sadkov, G. A. Bogatkin, B. N. Chikhachev and N. I. Ivanov, Tsentral Scientific Production Association, Chkalovsk, USSR)

[illegible] Although development of methods for the active monitoring of atmospheric gaseous components and realization by the differential absorption method is in the highest priority, the use of a number of environmental parameters and properties, such as the overlapping of the absorption spectra of different gases and the dependence of the absorption coefficient on atmospheric pressure and temperature, have not been adequately analyzed or have not been considered at all. Accordingly, an evaluation was made of the role of these factors in the measurement of methane, both at 1.65 and 3.39 μm, where gaseous absorption is the strong interference factor, and also of water vapor, which coincides with the atmospheric window of transmission at 1.65 μm and where appreciable gaseous absorption is observed at 3.39 μm. The results of measurements of the concentration of atmospheric methane using a LIDAR type are presented. Recommendations on taking gas samples of atmospheric water vapor, allowing for parameters are given. Figures 2, references: 10 Russian.

Combined Use of Spectral Brightness and Polarization Characteristics of Upward Radiation in Remote Sensing of Inland Bodies of Water

[illegible]

(Alexey Ya. V. Ivanov, G. A. Lukyanov, A. A. Mikhaylovsky, V. B. Pravdivtsev and S. O. Shiryaev, Institute of Electrical Engineering, Institute of Low Activity, Russian Academy of Sciences, St. Petersburg)

[illegible] This article presents the results of simultaneous measurements of upward radiation energy parameters using a hand-held spectrograph and Luch (Ray) polarization measurements were made in a channel that corresponds with the effective wavelength which is based on spectral brightness measurements, can be used with the degree of polarization for remote sensing of inland bodies of water with various optical characteristics. Multiple regression equations are calculated that link the relative concentrations of the water with the effective wavelength and the degree of polarization of upward radiation. Figures 3, references: 7 Russian.

Circulation of the Upper Layer of the Central and Eastern Basins of the Mediterranean According to Data of Ship and Satellite Observations in Autumn-Spring 1990 and 1991

[illegible]

(Alexey Ya. A. Ivanov, V. S. Ivanchikov and N. M. Lotov, Institute of Marine Hydrophysics, Ukrainian Academy of Sciences, Sevastopol)

[illegible] This article analyzes the results of ship and satellite observations of the hydrological structure and large-scale dynamics of water in the central and eastern basins of the Mediterranean Sea during February-April 1990 and January-March 1991, respectively. Maps of the sea surface temperature, temperature variations in the upper layer, and dynamic topography were constructed with special consideration of the complex temperature of the sea. These determinations were compared with data from ship and satellite measurements. There was a good agreement in the fields of dynamic topography and geostrophic currents in the surface and temperature maps of sea surface temperature. The preliminary, a complex and detailed study of the circulation of waters of water. Cloudy patterns of circulation in eastern and west-eastern directions were found in the central basin. An intense cyclonic current was noted in the Ionian Sea with a speed of 150-200 cm/s. In the eastern a southern area gyres. There is presented the Rhodes subbasin gyres. Temperature variations and anomalies are described. Three anticyclonic eddy formations were found which play a decisive role in circulation transformation. Geostrophic currents were found in northwestern. Figures 4, references: 6 Russian.

Ecological Monitoring of the Territory of Moscow Using Data From the IR Thermal Channels of an Aircraft Scanner

[illegible]

[illegible]

[illegible] The aircraft environmental scanning system was used over Moscow in mid-summer to measure in the IR channels. Day and night photographs were taken at an altitude of 4 km. In the night photo, a resolution of 25 m was achieved. The distribution of large industrial complexes was compared with the heat losses of individual regions of the city were compared. For quantitative analysis, most detailed digital thermal images were used. The detection method was able to find 25 previously known sources of discharges into the Moscow River. It was shown that the method can be used periodically to evaluate the ecological state of the region. Bibliography: 7 titles.

Extrapolation of Drilling Data Using Nonlinear Filtering of Aerospace Images of the Earth's Surface

927N0089D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 18 Jun 91) pp 41-47

[Article by I. V. Kalinin and I. V. Terentyev, Central Surveying Expedition, Yakutskgeologiya Polar Geophysical Observatory, Yakutsk; Research Institute of Aerospace Geological Methods, St. Petersburg; UDC 528.85:528.8:778.431]

[Abstract] It is shown that it is possible to use nonlinear filtering of aerospace information to increase the accuracy of extrapolation of data from Earth-based mesurements. An example is given, two images of one oil and gas bearing region of western Yakutiya. The images were synthesized into one image using various methods. Using a lineaments scheme it was established that, with a simple mask consisting of five points, the coefficient of correlation in a nonlinear third-order transformation could be increased to 0.9. In filtering of part of the image, the coefficient of correlation between Earth-based data and the transformed image of the region reached 0.7-0.8. Figures 7; references 5 (Russian)

Spectral Studies Using a 8-14 μm Field Spectrometer

927N0089E Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 28 Jan 91) pp 51-58

[Article by V. G. Surin, Research Institute of Aerospace Methods, St. Petersburg; UDC 528.813]

[Abstract] This article describes in detail the basis of a method to conduct spectral studies using a 8-14 μm field spectrometer. The method includes the construction of models of the object and measurement system, verification of the models in field conditions, measurement of radiation, normalization of the data, determination of the energy brightness of the object and background, and determination of the effective radiation coefficient and real radiation coefficient. Quantitative data may be obtained on the radiative characteristics of natural objects. No special temperature measurements are required, because a pyroelectric radiation receiver is used. The method was tested on geological objects in Central Kazakhstan, in particular, diorite rock. This method was also used to conduct spectral studies of other types of rock. The results indicate that the frequency and amplitude anomalies in the spectra recorded by the instrument have a real and specific cause. These anomalies manifest themselves in different ways when the experiment is carried out under different conditions. The deviation increases substantially when the temperature of the object differs substantially from air temperature. A systematic error in the determination of water temperature was also uncovered. Figures 6; table 1; references 14: 11 Russian 3 Western

Characteristics of Atmospheric Radiation Regime and Heat Exchange at Ocean Surface Under Continuous Cloud Cover

927N0081B Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 (manuscript received 30 May 91) pp 277-282

[Article by Ye. N. Leontyeva, Atmospheric Physics Institute, Russian Academy of Sciences; UDC 551.521;551.465.7]

[Abstract] This is essentially a continuation of an article by the author in the previous number of this journal (IZV. AN SSSR: FAO, Vol 28 No 2, pp 151-157, 1992). Estimates were made of the radiation regime in three atmospheric layers (above clouds, clouds, below clouds) and the heat balance at the ocean surface was determined using in situ data collected on the 35th cruise of the Akademik Kurchatov. Data are given on actinometric observations made by the author in the summer of 1982 in the Middle Atlantic region when predominantly stratocumulus clouds were present. A previously developed model of the aerosol-cloud atmosphere was used in computing the fluxes of short-wave radiation and earlier proposed methods for computing the profiles of thermal radiation made it possible to describe the atmospheric radiation regime. In the method used in computing integral short-wave radiation the optical depth of the cloud layer is first determined from the total solar radiation measured by a selective pyranometer without a filter in the region 0.38-0.71 μm. Then measurements of humidity and aerosol optical depth are used in computing the profiles of descending and ascending integral fluxes. The method used in computing long-wave radiation was the same as in the first part of the study. Since only optically dense clouds are considered, they are assumed to be ideally black emitters. The profiles of atmospheric parameters are determined from the results of aerological sounding. The quantities of heat absorbed by the ocean under different conditions are determined from in situ data on radiation and turbulent fluxes at the surface. Figure 1; references 7: 6 Russian, 1 Western.

Statistical Properties of Illumination in Image Plane in Lidar Sensing of Sea Surface

927N0081C Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 pp 319-324

[Article by V. I. Ivanov and A. N. Lazarchik, Scientific Research Institute of Nuclear Problems; UDC 551.463.5]

[Abstract] The objective of the study was research, within the framework of the first two moments, on the statistical properties of field intensity in the image of a sea surface illuminated by coherent optical radiation and the derivation of simple asymptotic expressions for the indicated moments with different relations of the surface parameters and the sounding geometry. The basis for the

work was a lidar sensing scheme described earlier by the authors in IZV. AN SSSR: FAO, Vol 26 No 11, pp 1205-1210, 1990. A source of coherent radiation at a stipulated altitude above the water surface generates a downward-directed Gaussian beam with a given effective light spot radius. An optical detector positioned coaxially with the radiation source at a different altitude has an optical system consisting of a lens with a pupil function of the Gaussian type which forms a sharp surface image in a plane situated at a given distance from the lens. Formulas are derived for the mean value and intensity correlation function in the image plane. The asymptotic form of the derived formulas for different limiting values of the statistical and geometric parameters of the experiment was investigated. The presented analysis of the statistical properties of illumination in the image plane of the lidar optical system during sea surface sensing shows that under definite conditions these properties can be used in evaluating the statistical parameters of the surface. In particular, the mean intensity in the image plane makes it possible to estimate the density distribution of sea surface slopes if the divergence of the sensing ray considerably exceeds the dispersion of slopes. The derived formulas can be used in determining the accuracy of such an evaluation and in selecting the optimum sensing scheme. Figure 1; references 7: 6 Russian, 1 Western.

Television Reporting Aerospace Survey

927N0095A Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 2, Feb 92 pp 21-25

[Article by B. N. Rodionov; UDC 528.711.1(202)]

[Abstract] A television reporting aerial survey is a new remote sensing method for monitoring the state of agricultural resources. It involves a survey of agricultural areas from light aircraft using portable TV cameras with registry of images by a portable VCR. Simultaneously the operator-observer dictates and enters on the videofilm comments on the degree of development of plants, their damage and anomalies. The videofilm can be played on ordinary TVs. The method combines the reliability of instrumental observations with the on-line character of TV reporting and is available to a wide range of users. The first TV reporting experiments were carried out at the Moscow Institute of Land Survey Engineers in 1980-1982. Later the system was developed at the All-Union Scientific Research Center for Developing and Operating the "AIUS-agroresursy" Data Management System. The survey is made with a constant TV camera focal length; in case of necessity the operator discriminates detail. The great range of available resolutions makes it possible to evaluate the state of both individual agricultural crops and fields as a whole. During 1988-1989 the method was used on an experimental basis from the "Mir" orbital station with direct transmission of the image through space and surface communication lines directly to users. This was done using the "Niva" TV outfit, consisting of a TV camera, VCR, monitor and communication line. The image detail was 40-50 m on the ground with a swath width 25 km. The resulting TV photographs made it possible to evaluate large anomalies in the development of agricultural crops, seasonal variations of reservoirs and irrigation systems, centers of salinization, zones of pollution around populated places and other ecological phenomena. These experiments were continued in 1991 using devices for compensating image shift, making it possible to obtain a surface resolution of 10 m. Both the small aircraft and spacecraft variants constitute an inexpensive means for on-line remote sensing of agricultural resources. The geometric and brightness characteristics of the TV reporting image are discussed in detail. Factors governing accuracy of the product, processing and interpretation procedures are outlined. Figures 2.

Image Spectrum of Sea Surface Formed by Synthesized Aperture Radar

927N0084A Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 32-36

[Article by M. B. Kanevskiy, Applied Physics Institute, USSR Academy of Sciences, Nizhnyy Novgorod; UDC 551.46.086:629.78]

[Abstract] In an earlier study (ISSLED. ZEMLI IZ KOSMOSA, No 4, pp 12-18, 1990) the author examined nonlinear transformation of the spectrum of sea waves into their image spectrum obtained using a synthesized aperture radar with numerical computations made using a simplified model function of the correlation of orbital velocities. Now, however, as the basis for computing the spectrum of the SAR image of the sea surface use is made of the spectrum of rises published by K. Hasselmann, et al. (DEUTSCHE HYDROGRAPHISCHE ZEITSCHRIFT, Reihe A, No 12, pp 1-95, 1973), obtained in an in situ experiment, being a generalization of the Pierson-Moskowitz spectrum. It is shown that the mechanism of formation of the sea surface image when using such a radar is nonlinear regardless of the directions of wave propagation, other than those close to radial (this makes problematical a detailed retrieval of the wave spectrum from its SAR image and the possibility of retrieving the parameters of the model spectrum seems more realistic). The spectra of the SAR image of waves propagating in an azimuthal direction, with allowance for speckle noise, are found. A definite approach for solution of the inverse problem is discussed. Figures 2; references 7: 3 Russian, 4 Western.

Accuracy in Determining Ocean Surface Temperature and Its Variations by Spectral Methods in Satellite Microwave Radiometry

927N0084F Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 107-121

[Article by A. G. Grankov and A. M. Shutko, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow; UDC 551.463.629.78]

[Abstract] The effectiveness of microwave radiometry methods for determining ocean surface temperature (OST) based on the spectral regularities in the interrelationship between the field of characteristic microwave radiation of the ocean-atmosphere system in the range of centimeter waves and hydrometeorological parameters is analyzed. OST is determined using the contrast (amplitude) principle for measuring the microwave radiation characteristics simultaneously in several parts of the spectrum. Estimates of the accuracy in determining OST and its variations attained using satellites of the orbital type are given and the conditions under which the potential accuracy can be realized for this range and operating mode are examined. Computed estimates of the accuracy in determining the instantaneous, synoptic and seasonal variations of OST when making observations from geostationary satellites are presented. It is shown that despite the considerable progress attained during the last decade in the field of satellite radiometry methods and apparatus for sensing OST appreciable discrepancies persist between the computed estimates of accuracy in its determination and experimental results. Programs in place in a number of countries indicate that in the early 1990's there should be an activity burst similar to that which occurred in the late 1970's-early 1980's. This should facilitate progress along a whole series of fronts which are defined and discussed in the conclusion. Figures 6; references 104: 62 Russian, 42 Western.

External Calibration of Low-Contrast Microwave Radiometry Measurements From Artificial Earth Satellite and Determination of Ocean Surface Temperature

927N0084B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 37-45

[Article by B. Z. Petrenko, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow; UDC 551.521:629.78]

[Abstract] The ineffectiveness of existing methods for the processing of radiothermal measurements in a case when high radiothermal contrasts are absent in the processed file is analyzed. It is shown that the traditional linear external calibration method makes it possible to obtain only biased evaluations of the calibration coefficients. Special indices of the contrast of measurements for individual channels and for the entire processed file of measurements determining the relative bias of evaluations of the scale factors are introduced. This bias is small when processing high-contrast radiothermal measurements well supported by a priori information, but increases with a decrease in the contrast of the measurements due to the exclusion of land regions from the processing. A nonlinear method was developed for processing radiothermal measurements based on the use of a special calibration relation. It is shown that this nonlinear method makes possible the effective retrieval of ocean surface temperature without use of land regions for external calibration. However, if the latter are used, both methods (linear and nonlinear) ensure an approximately identical accuracy in determining ocean surface temperature. Figure 1; references: 8 Russian.

Adaptive Algorithms for Estimating Content of Chlorophyll 'a' in Phytoplankton Using Remote Sensing Data for Mesotrophic and Eutrophic Water Bodies

927N0084C Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 20 May 91) pp 46-51

[Article by I. Yu. Kamov, Hydrochemical Institute, Rostov-na-Donu; UDC 551.46.0:629.78]

[Abstract] The optimum wavelengths for statistical determination of the content of chlorophyll "a" in phytoplankton are those pairs λ_1, λ_2 of wavelengths, $680 < \lambda 1 < 720$ nm for which the mean spectral brightness coefficients coincide. Evaluations of the sensitivity and results of application of the formulated algorithms to two files of experimental data are presented. The choice of the optimum wavelengths for the proposed adaptive algorithms is not dependent on the specific form of the dependence of the spectral brightness coefficient on the optical indices: it is only necessary that there be a smoothness of this dependence and a small spectral variability of both the scattering phase functions at angles greater than $2\pi/3$ and backscattering of radiation by mineral suspensions. Using an expression cited in the article it is possible to evaluate the influence of the spectrally dependent index $\beta(\lambda)$ on the quality of the adaptive algorithms. The influence of the chlorophyll fluorescence effect (which is dependent on the physiological state of the cells) on the adaptive algorithms is taken into account. The volume of experimental data used in testing the adaptive algorithms was inadequate for reliable confirmation of any theoretical conclusions but provides a basis for further empirical investigation of the proposed algorithms. Figure 1; references 9: 7 Russian, 2 Western.

Analytic Model of Deviations in Coordinates of Points on Pseudoframe Obtained in Scanner Survey of Earth's Surface

927N0084D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 20 May 91) pp 52-61

[Article by V. F. Petrishchev; UDC 528.714.2]

[Abstract] When making a frame survey from an artificial earth satellite the deviations in coordinates of stipulated points on the image are dependent in a general case only on three deviations in the survey camera spatial position and three deviations in the parameters of its orientation along each of the coordinate axes. In a scanner survey the considered deviations in coordinates must also be dependent on deviations in the velocities of translational and rotational motions of the space

camera, that is, must be functions of a 12- (rather than a 6-) dimensional vector of deviations in the elements of outer orientation. The problem of constructing a model of deviations in a scanner survey is therefore more complex than in the case of a frame survey. Taking into account the great diversity of scanner survey methods, as well as the available models of survey camera motion, it must be expected that there will be a corresponding diversity of models of deviations in a scanner survey. This makes it impossible to solve the problem of constructing a unified model of deviations in a scanner survey, in contrast to the case of a frame survey. Accordingly, a quite general approach to solution of the formulated problem is proposed which is applicable to a very simple case of survey camera motion. Only in the presented very simple case is a finalized solution of the problem possible. The proposed analytic model of deviations is represented in a linear discrete form. The constructed linear model of deviations in the coordinates of points on a so-called pseudoframe was possible only by the choice of a simplified model of survey camera motion and the conditions for the scanning of a local sector. This procedure cannot be applied to the case of panoramic scanning. Figure 1; references: 5 Russian.

Global On-Line Space Monitoring of Atmospheric Ozone

927N0084E Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 7 Jan 91) pp 72-78

[Article by A. I. Kot, A. M. Lyudchik, A. N. Krasovskiy and A. F. Chernyavskiy, Scientific Research Institute of Applied Physical Problems imeni A. N. Sevchenko, Minsk; UDC 551.510.534]

[Abstract] Data from the Nimbus ozonometric satellite indicate that satellite observation methods are the sole effective means for monitoring the state of atmospheric ozone. However, data of the type supplied by Nimbus have only a local character, limited to the satellite trajectory, and cannot be used in on-line monitoring of the state of the ozonosphere above the Earth's entire surface. Accordingly, a study was made of the possibilities of a method for on-line global monitoring based on atmospheric spectral brightness in the UV spectral range. Since only one spectral interval is used, quantitative information on ozone distribution is largely lost and it is only possible to make a qualitative analysis of the state of the ozonosphere over different sectors of the Earth's surface with detection of regions of significant anomalies, such as the Antarctic ozone hole. The Nimbus system and the new approach supplement one another. The essence of the proposed method is that a satellite in a quite distant orbit carries an optoelectronic instrument forming and registering the image of the visible surface of the Earth in a narrow (several nanometers) spectral interval in the wavelength region λ less than or equal to 300 nm. In this case the fraction of radiation reflected from the Earth's surface is negligible in comparison with the radiation scattered in the atmosphere and the optical characteristics of the surface exert no influence on the distribution of atmospheric brightness. Under such conditions the brightness of a pixel is determined by the conditions for illumination of the corresponding part of the atmosphere by the sun, vertical distribution of ozone and choice of the observation wavelength. Since the illumination conditions change monotonically from pixel to pixel it is natural to relate all the spatially limited brightness fluctuations detected in the image to anomalies in atmospheric ozone distribution. The effectiveness of the method is illustrated by model computations. Figures 3; references 12: 5 Russian, 7 Western.

Integral Atmospheric Short-Wave Radiation Fluxes Over Continuously Cloud-Covered Ocean

927N0080A Moscow IZVESTIYA AKADEMII NAUK SSSR. FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 2, Feb 92 (manuscript received 12 Feb 91) pp 151-157

[Article by Ye. N. Leontyeva, Atmospheric Physics Institute, Russian Academy of Sciences; UDC 551.521.1]

[Abstract] A study was made to determine solar radiation fluxes in the atmosphere over the ocean when there is a continuous cloud cover. Data were used from standard shipboard actinometric and meteorological observations. A method was developed for computing the solar component of the atmospheric radiation regime using these data. In order to solve the formulated problem it was necessary to prepare optical models of an aerosol atmosphere and clouds, then compute the fluxes and compare the results with measurements of the total solar radiation incident on the surface. The total radiation in clouds computed as a function of optical depth and solar zenith angle makes it possible to formulate the inverse problem: by measuring the total radiation and knowing the solar zenith angle, determine the optical depth. On this basis a model of an aerosol- cloud atmosphere was developed for computing the profiles of fluxes of direct, diffuse and total radiation and ascending short-wave radiation in the atmosphere above an ocean with a single cloud layer situated at an arbitrary altitude. The sensitivity of the fluxes at the surface and outgoing radiation at the upper boundary of the atmosphere to the main input parameters was examined. Experimental quantities of total radiation at the ocean surface in the Middle and Tropical Atlantic are compared with data computed using the proposed model under conditions of continuous Sc and As cloud cover. Figures 7; references 7: 3 Russian, 4 Western.

Research on Characteristics of Temperature-Wind Changes in Radiobrightness Temperature of Wave-Covered Sea Surface

927N0080B Moscow IZVESTIYA AKADEMII NAUK SSSR. FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 2, Feb 92 pp 196-203

[Article by A. K. Arakelyan, Radio Physics and Electronics Institute, Armenian Academy of Sciences; UDC 551.465.6]

[Abstract] It was shown in earlier studies that in addition to wind speed water temperature exerts a significant influence on the wind wave formation process, making it necessary to carry out research on changes in the radiothermal characteristics of the sea surface caused by temperature changes in the spatial spectrum of surface waves. Allowance was made for the temperature dependence of the spatial spectrum of wind waves, being a corollary of changes in stratification conditions and the viscous dissipation of short wind waves with temperature. Methods are proposed for microwave radiometry sensing for determining the speed of the near-surface wind and water temperature. It is concluded that the temperature increment of radiobrightness temperature of the wave-covered sea surface is attributable to temperature changes of the permittivity of water and the spectrum of wind waves. The temperature increments of both the radiobrightness temperature and the emissivity of the sea surface are commensurable with the wind increments of these quantities. The maximum of the temperature changes falls in the radio wave range 3- 10 cm. For the precise remote determination of wind speed and water temperature by microwave radiometry methods it is necessary to carry out two-position, two-frequency or bipolarization measurements of sea surface radiobrightness temperature. Figures 6; references 17: 11 Russian, 6 Western.

Determining Atmospheric Aerosol Optical Depth From Surface Measurements of Direct Integral Solar Radiation

927N0039C Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12 Dec 91 (manuscript received 4 Apr 91) pp 66-71

[Article by T. A. Tarasova and Ye. V. Yarkho, Central Aerological Observatory; UDC 551.521.31]

[Abstract] Simple formulas are proposed for computing atmospheric aerosol optical depth at a wavelength 0.55μm using data on direct integral solar radiation measured with an actinometer. An estimate was made of the possible errors of the method attributable to the inadequacy of data on the spectral behavior of the aerosol extinction coefficient. The use of the results of observations of direct solar radiation S at stations is difficult due to the lack of precise data on atmospheric moisture content because the actinometric and aerological networks rarely coincide. This problem can be solved using empirical relations between moisture content and water vapor elasticity at the surface in different regions. An error in determining spectral aerosol optical depth of less than 0.05 can be attained when using data on moisture content w determined with an accuracy to 0.5 g/cm^2 in the dry atmosphere with w < 1 g/cm^2 and with an accuracy 2.5 g/cm^2 in the moist atmosphere when w is equal to or greater than 1 g/cm^2. Determination of the spectral aerosol optical depth with an accuracy greater than 0.05 is infeasible. The method was checked by using 86 instantaneous S values obtained during a period of an experiment for studying the radiation properties of cirrus clouds. Four method variants were compared and all gave very close results. The good consistency of the different variants makes it possible to recommend formula (4) derived in this study for the processing of network observations. Figure 1; references: 9 Russian

Statistical Characteristics of Atmospheric Transparency Coefficient on Slant Paths

927N0039D Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 24 Jan 91) pp 72-76

[Article by Ye. R. Milyutin and Yu. I. Yaremenko, Leningrad Communications Electrical Engineering Institute; UDC 551.591.36/6]

[Abstract] The results of actinometric measurements were used in determining the time regularities of change in the atmospheric transparency coefficient on slant paths. Files of data from direct solar radiation measurements made at Voyeykovo during 1980-1982 were subjected to statistical processing. This required computation of the relative transparency coefficient, broken down into 19 intervals. Tabulated data on integral intensity of solar radiation at the ground surface and the transparency coefficient as a function of solar angle of elevation for the ideal atmosphere were used in the process. Tabulated data are given for the monthly and mean annual statistical characteristics of the relative transparency coefficient. During winter the mean value is less than the mean annual value, whereas in spring and summer it is greater. Two characteristic situations with different observation conditions are distinguished. A computer analysis made it possible to determine that with the presence of clouds of any type on a slant path the empirical distribution of the atmospheric transparency coefficient is approximated well by a truncated Rayleigh distribution, but in the case of absence of clouds—by a modified beta distribution. By applying this method it is possible to solve modern scientific problems, such as determining the effective lifetime of modern systems for transmitting information in the optical range. Figure 1; references: 9 Russian

Thermal Effects of Mixing of Sea Waters With Different Temperatures and Salinities

927N0054B Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 10, Oct 91 (manuscript received 19 Nov 90) pp 88-93

[Article by A. G. Zatsepin, A. D. Krylov and N. A. Maksimenko, Oceanology Institute, USSR Academy of Sciences; UDC 551.465.4:551.463.6]

[Abstract] The thermodynamics of the process of mixing of sea waters with different temperatures and salinities is examined. An integral equation for the budget of enthalpies is written and solved numerically. The results of computations of the thermal effects of mixing are

approximated by simple polynomials. It was established that the temperature of the mixture may deviate from the arithmetical mean temperatures of the mixing water masses (with allowance for the proportions) by as much as 0.1°C. However, the real contribution of this deviation to the effects of increased density with mixing, as well as ice formation within the water during mixing, is scarcely substantial. The thermal effects of mixing of different water masses in the world ocean are extremely weak, although in some cases they may attain entirely measurable quantities. However, it is impossible to make a direct comparison between the model considered in this article and the results of in situ observations. Under natural conditions in regions with a marked salinity stratification the adiabaticity condition may not be satisfied; an increasing mixing time results in considerable interaction with adjacent layers and the atmosphere and the effects of differential diffusion of heat and salt at different rates become important. These effects are manifested most strongly during the supercooling of the upper layer when it comes into contact with the lower, more saline layers. Figures 3; references 10: 6 Russian, 4 Western.

Some Results of Lidar Determination of Slant Visibility Parameters at Airfield

927N0047B Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 9, Sep 91 (manuscript received 28 Sep 90) pp 18-25

[Article by Ye. Ye. Rybakov, V. A. Kovalev, A. S. Pak and Ye. E. Mozharov, Main Geophysical Observatory; Zenit Scientific Production Association; UDC 551.591.6:551.501.816]

[Abstract] Practical tests of the "Elektronika-06R" lidar, a modernized variant of a lidar instrument for measuring the range of slant visibility, were carried out in the autumn of 1989 at Ulyanovsk airport. The lidar modernization involved replacement of the analog registry system and processing of the signals in a digital registry system (on-line computer data processing). The objectives of the research were testing of algorithms for processing lidar signals and a method for determining visibility using a lidar directly at an airfield. A direct comparison also was made of the results of lidar measurements of the altitude of detection of airstrip ground reference points and lights with data from visual observations from aboard aircraft at the time of landing and also the results of measurements of the altitude of the lower cloud boundary made with standard cloud altitude recorders forming part of KRAMS meteorological systems. Another objective was refinement of working algorithms and individual parts of the measurement method and gathering statistical data in slant directions under different meteorological conditions. A diagram of positioning of the instruments at the airfield is presented and the results of the comparisons are given. There was a good agreement between lidar sounding data and visual observations from an aircraft. The results are preliminary and require careful checking under a wide range of weather conditions. Figures 5; references 9: 8 Russian, 1 Western.

Simplex Method in the Problem of Optimization of the Phase of a Light Beam in a Nonlinear Medium

927N0091A Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 26 May 91) pp 1249-1253

[Article by I. V. Malafeyeva, I. Ye. Telpukhovskiy, and S. S. Chesnokov, Lomonosov Moscow State University; UDC 535.416.4]

[Abstract] Adaptive and programmatic means of beam control are used to compensate for the distortions of a light wave associated with nonlinear refraction and turbulent fluctuations of the index of refraction of the medium. The problem of control is one of searching for the phase of a light beam at which the quality criterion of radiation in the observation plane acquires an extreme value. Aperture sensing is typically used in quasi-stationary conditions. This makes it possible to optimize any criterion reflecting the control goal. However, gradient procedures typically only find the local extremum of the quality criterion. Phase control methods need to be developed on the basis of procedures which do not require calculation of the gradient of the target function. This article studies the effectiveness of adaptive compensation of stationary wind refraction of a light wave based on the simplex method. Simple optical aberrations are used as the basis modes of control. The control goal function is taken to be the focusing criteria that characterize the concentration of a light field in a given observation plane. The simplex method is found to reach the extremum more quickly, which may further improve the search strategy. The simplex method reliably finds the maximum of the target function with a previously determined accuracy. This makes it possible to increase the speed of adaptive systems without adding more complex equipment. The number of measurements of the target function (compared with gradient procedures) can be reduced by a factor of 1.5-2. Figures 2; table 1; references 3 (Russian).

Some Questions on the Compensation of Nonlinear Distortions of Optical Radiation. Algorithms of Adaptive Control

927N0091B Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 18 Sep 91) pp 1265-1272

[Article by V. A. Trofimov, Lomonosov Moscow State University; UDC 621.373]

[Abstract] This article provides an overview of algorithms presently used to control the parameters of light radiation and their implementation in numerical experiments to compensate for nonlinear distortions. The reasons for the divergence of the phase conjugation algorithm are discussed. The dependence of the results of focusing (according to this algorithm) on the integration step along the longitudinal coordinate is illustrated. Hysteresis dependences are obtained for the strength of optical radiation received at an aperture in relation to the initial strength of the

light pulse. The following issues are also addressed: control of a light beam wave front, delay in control channels, nonlinear interaction of two waves, flexible and segmented mirrors, and selection of an optimal beam profile. A relatively new class of problems is discussed, the distortion of the amplitude-phase characteristics of optical radiation due to a change in the composition of matter through a chemical reation in the region of the beam. Figures 2; table1; references z: 35 (Russian).

Invariant Relationships for the Thermal Blooming of Optical Radiation

927N0091C Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 16 Apr 91) pp 1278-1280

[Article by V. A. Trofimov, Lomonosov Moscow State University; UDC 621.378.326]

[Abstract] Several invariants and invariant relationships are obtained for the thermal blooming of light beams in a moving medium and of light pulses in a stationary medium. The invariants may be expediently used to monitor the results of numerical modeling of thermal blooming of optical radiation. References 8 (Russian).

The Gradient Method in the Problem of Minimizing the Angular Divergence of Light Beams

927N0091D Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1281-1283

[Article by S. S. Chesnokov, Lomonosov Moscow State University; UDC 621.378.3]

[Abstract] The most promising means of controlling the phase front in the transmitting aperture (to decrease angular divergence) is determination of the initial phase profile of the beam while numerically solving the optimization problem using gradient methods. The problem of optimal control consists of the determination of those system parameters which provide the required conditions for the interaction of radiation with matter. One can minimize the angular divergence at a distance by maximizing at a sufficiently remote target the relative proportion of light strength concentrated in a given solid angle using the spectral criterion. Calculations show that the effectiveness of the optimization algorithm depends greatly on the proportion of energy focused in a given solid angle. The peak intensity in the object varies in an iteration process One can construct an iterative procedure to find the optimal phase using an arbitrary gradient. The effectiveness of the algorithm is demonstrated in the example of compensating for stationary wind refraction. The spectral criterion can be increased by 10-15 percent by varying the proportion of focused energy. The peak intensity can be increased by 20-30 percent. References 3 (Russian).

Possibility of Controlling the Phase of Optically Coupled Lasers

927N0091E Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1284-1289

[Article by V. P. Kandidov, I. V. Krupina, and O. A. Mitrofanov, Lomonosov Moscow State University; UDC 621.373.826]

[Abstract] One promising means of obtaining high-quality strong laser radiation is the use of modularly-constructed multi-beam laser systems. The frequency and phase synchronization of modules enables coherent addition of fields. This substantially increases the power density of total radiation at a distance. Experimental and theoretical studies have noted the strong effect of the scatter of parameters (i.e., optical length) of individual lasers on the effectiveness of phase synchronization. Compensation of distortions and active control of the phase profile is an acute problem. This article theoretically examines the effect of detuning the optical lengths of lasers on the structure and threshold amplification of field distributions of diffractionally-linked lasers. The response function is calculated for the phase of the outgoing radiation. A periodic array of diffractionally-linked lasers is used to analyze the problem. It is shown that it is possible to control the phase profile and the mode composition of the outgoing radiation of optically coupled lasers by varying the detuning of their optical lengths. Figures 4; references 9: 7 Russian 2 Western.

Limits of the Possibilities of Adaptive Correction of Wind Refraction Using Modal Control

927N0091F Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1290-1293

[Article by I. Ye. Telpukhovskiy and S. S. Chesnokov, Lomonosov Moscow State University; UDC 621.378.3]

[Abstract] Based on a numerical model of an adaptive system of aperture sensing, the dependence of the beam focusing criterion on the number of basis modes used in wave front control is analyzed. The problem is limited to compensation of the stationary wind refraction of a Gaussian beam. It is found that the maximum degree of compensation of thermal defocusing is defined by the product of the path length and the nonlinearity parameter. As path length decreases, there is a simultaneous increase in the relative contribution of third- and fourth-order modes. Figures 4; references 2: 1 Russian 1 Western.

Numerical Modeling of a Ground-Based Adaptive Telescope

927N0091G Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 26 Sep 91) pp 1298-1302

[Article by V. P. Lukin, N. N. Mayer, and B. V. Fortes, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk; UDC 538.566:551.511.6]

[Abstract] Among the ways one can improve the resolution of an astronomical instrument is measurement of distortions of the wave front and correction of these distortions in the process of observation (adaptive technique) This article examines a telescope equipped with a wave front distortion correction system. The effectiveness of phase correction of distortions introduced by atmospheric fluctuations in the refraction index in the formation of images of astronomical objects is studied. Two types of correctors are examined, modal and combined. Two methods of modeling the phase distortions are described. One is based on the generation of a spectral amplitude ensemble, and the other is based on the generation of random aberration coefficients. A combination of these methods was used in the calculation. Figures 3; references 11: 3 Russian 8 Western

Numerical Study of Phase Characteristics of Reflected Waves in the Atmosphere

927N0091H Moscow OPTIKA ATMOSFERY in Russian Vol 4 No 12, Dec 91 (manuscript received 27 Sep 91) pp 1318-1320

[Article by P. A. Konyayev, V. P. Lukin, and S. Yu. Tabakayev, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk]

[UDC 621.378.325]

[Abstract] Numerical modeling methods are used to study the propagation of waves in a turbulent atmosphere with reflection off a specular object of finite size. The fluctuation characteristics of the phase of a Gaussian beam are examined. Attention is focused on the effect of amplification of phase fluctuations. The amplitude-phase characteristics of direct and reflected waves and in particular, the transverse distribution of the average intensity, the dispersion of intensity fluctuations, and the structural phase function are studied using statistical testing by averaging over the solutions of the dynamic part of the problem. The behavior of the amplification coefficient of phase fluctuation depends on the separation of observation points, on the intensity of turbulence, and the reflector. The amplitude curve has two types of behavior: a gradual increase and a saturation section. In the saturation region the amplification coefficient characterizes the ratio of dispersions of phase fluctuations. In the region of high intensity fluctuations there is no amplification of phase fluctuations on a path with reflection. In the region of low intensity fluctuations, the intensity of phase fluctuations is higher for a small reflector and for small separations. The increase in amplitude occurs faster for a smaller reflector. In a region of intermediate fluctuations, the amplitude curve behaves the same as the weak fluctuation section. Figures 2; table 1; references 3 (Russian).

Influence of Conditions for Observing Surface Features on Their Effective Thermal Contrast

927N0099A Leningrad OPTIKO MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 91 (manuscript received 17 Jul 90) pp 24-25

[Article by V. A. Ovsyannikov, candidate of technical sciences, R. I. Sitdikov and G. N. Khitrov, State Applied Optics Institute, Kazan]

[Abstract] The ΔT_R quantity is the principal parameter determining the possibility of observing objects by means of thermal imaging units. Since the user usually has only data on the temperature difference $\Delta T = T_0 - T$ and the difference of the radiation coefficients $\Delta\varepsilon = \varepsilon_0 - \varepsilon$ of the object and the background in the spectral working range $\Delta\lambda$ of a thermal imaging unit, the objective of the study was a determination of the relationship between these ΔT and $\Delta\varepsilon$ values and the corresponding ΔT_R quantity for different positions and different conditions for illumination and observation of surface objects with diffusely reflecting surfaces for the most widely used range $\Delta\lambda = 8...14$ μm. A very simple approximate formula is derived for estimating the effective difference of the radiation temperatures of surface objects and the background detected by a thermal imaging unit of any type which can be used in practical work. With approach of the ambient radiation temperature to that for the background of the object the ν quantity in this formula decreases at the limit attaining a virtually zero value. A table gives ν values which can be used in approximate routine computation of the effective thermal contrast of surface objects for their different positioning and observation conditions (such as in open terrain, in forest glades and amidst trees). References: 5 Russian.

Induced Raman Scattering of Focused Pulsed Laser Radiation Beam in Atmosphere

927N0096A Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 11, Nov 91 (manuscript received 9 Aug 91) pp 1123-1127

[Article by M. F. Shalyavev and V. P. Sadovnikov, Electronics Institute, USSR Academy of Sciences, Moscow]

[UDC 538.576.4:621]

[Abstract] A theoretical study was made of the induced Raman scattering (IRS) of focused short pulsed laser radiation beams propagating along atmospheric paths. The focusing of laser beams on atmospheric paths considerably increases the efficiency of IRS. In the beam focal region this results in the total depletion of the incident radiation (IR), blocking its further propagation. In case of necessity it is possible to localize the IRS effect on a stipulated segment of the path, which can be used in a number of practical problems. For example, as in creating a region on the path after which the propagation of radiation of two wavelengths begins, at the wavelength of the IR and the wavelength of the Stokes component (SC), or only the SC. In the atmospheric propagation of laser radiation allowance for the influence of IRS on

nitrogen molecules may be essential not only in problems relating to the transmission of powerful laser radiation, but also in atmospheric sounding problems. A very important consideration is the competition of IRS in the rotational and vibrational transitions of molecules. Whereas IRS in the vibrational transitions of nitrogen molecules exerts an influence for tens of kilometers, IRS in the rotational transitions, for which the Raman scattering section is an order of magnitude greater than for the vibrational transitions, may be manifested for distances of only hundreds of meters. Figures 3; references 4: 2 Russian, 2 Western.

Laser Radiation Divergence in Regular Nonlinearly Refracting Medium

927N0096B Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 11, Nov 91 (manuscript received 31 Jul 91) pp 1203-1210

[Article by A. A. Zemlyanov and A. V. Martynko, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 621.378.325]

[Abstract] An approach based on use of equations for the effective parameters of a beam is proposed for obtaining quantitative expressions relating the angular characteristics of laser radiation in a nonlinear medium and the beam parameters and characteristics of regular inhomogenities along the path, as well as for investigating regimes for formation of the directional diagram of the radiation for situations corresponding to manifestation of nonlinear refraction effects in regular homogeneous and inhomogeneous media with linear absorption. The conditions are found for the existence of precise aberration solutions for the effective width, radius of phase front curvature and limiting divergence. A specific form of these solutions is presented. It was established that there is a similarity effect for processes transpiring under conditions of strong nonlinear distortions due to thermal blooming of collimated beams of different classes and different nonlinear interaction mechanisms. The regimes of formation of limiting divergence in initially homogeneous and inhomogeneous nonlinearly refracting media were investigated. Expressions relating the parameters of an inhomogeneous path and the initial parameters of laser beams were determined for a regime of weak nonlinear distortions. Figures 2; references: 11 Russian.

Correction of Lidar Signals With Their Interpretation Relative to Optical Characteristics of Scattering Media

927N0096C Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 11, Nov 91 (manuscript received 11 Mar 91) pp 1220-1226

[Article by M. M. Kugeyko, I. A. Malevich and D. E. Shiperko, Belorussian State University imeni V. I. Lenin; UDC 551.501.8]

[Abstract] A method is proposed for increasing the accuracy in retrieving the extinction coefficients of layered-inhomogeneous media by correcting the backscattered signals for any change in the lidar ratio. An algorithm is given for determining the correction coefficients. It is shown that the absolute value of the correction coefficient characterizes the degree of change in the qualitative composition of the scattering medium. The effectiveness of the proposed method is examined and the results of numerical simulation are presented. The practical significance of the proposed method is evident. Its use makes it possible with the highest accuracy to determine the β(z) profile in all sectors of media with interfaces (both in atmospheric and hydrospheric layers) when sounding from a carrier, in different layers of multilevel clouds, etc.). It is important that the β(z) reference values can be determined in the initial sections of the sounding path. Moreover, the use of the method for determining the calibration values from the measured backscattered signals described earlier by the authors in IZV. AN SSSR. FAO, Vol 26, No 3, pp 213-216, 1990 makes it possible to automate the experiment and on an on-line basis obtain [illegible]. Figures 4; references 5: 4 Russian, 1 Western.

Study of the Effect of Orientation of Aerosol Particles on Sounding Characterstics of Light Scattering

927N0070A Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 5 Feb 91) pp 1011-1016

[Article by R. F. Rakhimov and D. N. Romashov, Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 551.510.42]

[Abstract] Aerosol particles may acquire a variety of forms in clouds. Predominance of a particular orientation of the symmetry axes of aerosol particles may have an adverse effect on lidar response. Numerical modeling estimates are used to analyze the effect of a predominant orientation of cylindrical particles on lidar response. The polarization of the sounding radiation is also considered. Similar results are presented for a semi-disperse ensemble of ice crystals with characteristic particle sizes of 1.0 μm and 10.0 μm and a radiation wavelength of 1.06 μm. This article also presents an algorithm to calculate the bakscattering inversion matrix for an ensemble of arbitrarily oriented cylinders of finite length. The direction and extent of a predominant orientation of particles provides information on the direction and intensity of air currents, which may be used to develop optical methods to determine the state of the atmosphere at such remote altitudes. Figures 4; references 8 (Russian).

Resolution-Optimal One-Dimensional Image Filtering

927N0070B Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 8 Feb 91) pp 1030-1034

[Article by V. I. Solodushkin and V. A. Udod, Scientific Research Institute of Introscopy at the Kirov Polytechnical Institute, Tomsk; UDC 535.[illegible]]

[Abstract] The problem of optimal image filtering for maximum resolution is solved for one dimension. This solution may be used to improve images of objects through signal filtering in a scanning optical system working in a turbulent atmosphere with random refraction. Here a linear image system is used. The model structure consists of an initial image, a distortion filter, additive noise, a correcting filter, and an output image. References 18: 16 Russian 2 Western.

Active Restoration of Coherent Images From Phase-Distorted Signals

927N0070D Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 12 Feb 91) pp 1054-1060

[Article by R. S. Irgizov, A. A. Kovalev, and V. M. Nikitin, UDC 621.378]

[Abstract] A noniterative method is proposed to restore coherent images distorted by atmospheric turbulence. This method does not require a reference source in the image field. The basic method is space-time modulation of the sounding signal within the time interval of a "frozen" atmosphere. This modulation makes it possible to select phase distortions which do not change over time. Different ways of implementing the proposed active method are examined. One way is illustrated using the results of mathematical modeling. A general method for sounding at great distances and a more specialized approach for short-range sounding are presented. Figures 6; references 7: 5 Russian 2 Western.

Restoration of Two-Dimensional Fields of Atmospheric Parameters Using a Lidar Signal Reflected by the Earth's Surface

927N0070E Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 10 Jul 91) pp 1061-1065

[Article by V. P. Aksenov, V. A. Banakh, Ye. A. Yefimova, and O. V. Tikhomirova, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk, UDC 551.510.4]

[Abstract] It is possible to substantially reduce the power level needed to effectively sense the atmosphere by using a differential absorption signal from on-board lidar reflected from the Earth's surface with a tomographic data processing method. A sounding scheme is proposed and an algorithm is described for inversion of lidar data in order to restore two-dimensional fields of atmospheric parameters. The results of modeling are presented. The sensing scheme is similar to one used in geophysics to study rock massifs. The algorithm is a modification of an algorithm to process seismic tomography data. The modeling process is described. Results are preliminary and implementation of this method requires the development of more efficient algorithms that are more resistant to noise in the initial data. Figures 3; references 9 (Russian).

Power Received by Lidar in Atmospheric Sounding of a Surface With a Combined Scattering Index

927N0070F Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 7 May 91) pp 1066-1069

[Article by M. I. Belov and V. M. Orlov, All-Union Scientific Research Institute of Marine Fishery and Oceanography, Moscow, UDC 551.501]

[Abstract] Expressions are obtained for the power received during sounding in an optically dense aerosol atmosphere. The sounded surface has a complex scattering index with diffuse and quasi-specular components. It is shown that the received power depends on the ratio of the components. The more transparent the atmosphere, the more strongly the dependence manifests itself. In the calculations it is assumed that there are no changes in the reflectivity. Figure 1; references 7 (Russian).

Comparison of Lidar and Radar Methods of Sensing Wind Velocity

927N0070G Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 6 Jun 91) pp 1070-1078

[Article by B. D. Belan, G. G. Matvienko, A. I. Grishin, V. K. Kovalevskiy, and V. Ye. Meleshkin, UDC 551.501.7:551.508.82]

[Abstract] This article examines the determination of the accuracy of an instrument, including instrument error in the standard device and the tested device, as well as the issue of data averaging. Results of simultaneous sounding of the wind vector in the lower atmosphere using three-track lidar and the aerological "Meteor-RKZ" system are compared. Reasons for the selection of these devices are discussed. The lidar implemented a temporal correlation and spectral method of measuring wind velocity by the transfer of aerosol fields between the three sounding tracks. Measurements were made day and night, in various meteorological conditions, and at various wind velocities. The comparison showed a satisfactory coincidence of methods within 2.4 m/s and 32° in direction. Systematic, RMS, and weighted average deviations in speed and direction were considered. The sources of deviations are explained. Suggestions are offered on how to improve lidar characteristics. Figure 1; tables 3; references 14 (Russian).

Joint Interpretation of Lidar and Photometric Data in the Study of Cloud Fields From Space

927N0070H Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 10, Oct 91 (manuscript received 5 Jul 91) pp 1079-1088

[Article by Yu. S. Balin, S. I. Kavkyanov, and S. V. Strepetrova, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk, UDC 551.521.6:629.78]

[Abstract] This article discusses one possible implementation of a complex optical experiment using lidar and a radiometer from space. Lidar and photometric data are linked by models of the vertical stratification of stratiformis clouds. A closed numerical experiment is conducted which simulates a random cloud field on the background of an underlying surface with varied albedo. The results illustrate the possibilities of obtaining information through joint measurement. The vertical profile of the extinction coefficient in the cloud is described by an empirical equation. The algorithm used to interpret the data can determine optical and geometric parameters, distance, surface reflectivity, and the upper boundary and extinction coefficient at the upper boundary of the clouds. Three conclusions are reached. Photometric measurements do not always provide a reliable description of cloud fields. Lidar measurements substantially increase the reliability of the interpretation, but only with a rather high spatial measurement density. Combined use of lidar and photometric measurements permits an acceptable compromise between the required reliability of interpretation and the capabilities of real lidar systems. Figures 3; table 1; references 3 (Russian).

Measurement and Calculation System for Lidar Monitoring of Atmospheric Impurities

927M00704 *Tomsk OPTIKA ATMOSFERY* in Russian *Vol 4 No 10, Oct 91* [manuscript received 27 Jun 91] *pp 1106-1111*

[Article by P. V. Golubitskiy, Yu. P. Petrov, and O. A. Filatova, Lomonosov Moscow State University, Moscow; UDC 519.2:551.501.685.3].

[Abstract] This article proposes the creation of a measurement and computing system with the highest possible sensitivity or resolution based on existing lidar measurement systems. Concentrations of atmospheric impurities are determined using differential absorption. In analyzing a large complex nonlinear system one can use series-parallel decomposition into simpler components. An optimal algorithm is constructed for each type of component. The synthesis of an optimal algorithm to process lidar measurements makes it possible to use an existing experimental spectrum to calculate in real time the parameters of the spectral lines with a controlled error level. Figures 3; references 6: 3 Russian, 3 Western.

Dispersion Method of Determining the Zenith Angle of an Object Moving in the Atmosphere

927M00705 *Tomsk OPTIKA ATMOSFERY* in Russian *Vol 4 No 10, Oct 91* [manuscript received 27 Jun 91] *pp 1106-1110*

[Article by A. N. Shadrin; UDC 528.511].

[Abstract] Optical refraction in the atmosphere, which is manifested in the curvature of the trajectory of beams, makes it difficult to determine the true position of a moving object. In order to account for the effect of refraction one must know the altitude profile of the index of refraction of air along the propagation path of the beam. One can do this only by measurement or by using various statistical atmosphere models. Measurement is particularly difficult for objects moving along a curved path and an unknown trajectory. Models are rarely used because of error and the computer resources required. Methods using analytical models are similarly afflicted by error. A dispersion method reduces error in determining the true zenith angle. Proceeding from refraction theory for a spherically-stratified atmosphere, assuming the object is located using two-frequency optical radiation, an expression is obtained which makes it possible to estimate the true zenith angle of an object moving in the atmosphere. One must measure the index of refraction of the air at the observation point (or meteorological parameters) and visible zenith angles for radiation at the appropriate wavelength. Appropriate pairs of wavelengths are given for various zenith angle ranges. Error estimates are provided. Figures 2; references 3 (Russian).

Measurement of Wind Flow Speed Using Doppler Lidar Based on a One-Frequency TEA CO_2 Laser

927M00708 *Tomsk OPTIKA ATMOSFERY* in Russian *Vol 4 No 10, Oct 91* [manuscript received 27 Jun 91] *pp 1118-1117*

[Article by V. M. [illegible], N. N. Kalyuzhnyy, A. V. Pryezzhev, and Yu. Ya. Ponurovskiy, Lomonosov Moscow State University, Moscow; UDC 551.511].

[Abstract] Doppler lidar using quasicontinuous CO_2 lasers can measure wind flow parameters at distances of several hundred meters. Continuous Doppler lidar can be constructed like a Mach-Zehnder interferometer with one of the mirrors replaced by a scattering telescope. Device parameters are given. Continuous Doppler lidar can be used to a distance of about 1 km. Distance can be increased by using a pulsed TEA CO_2 laser with injection of an external signal and a narrow spectrum of generated radiation. A coaxial bistatic scheme is used for atmospheric sounding. A schematic is given. In sounding at distances over 2 km the problem of a detectable signal is encountered. This problem can be overcome by using an additive amplifier with a changing amplification. Sensing distance can be increased to over 10 km using a more complex monostatic sounding system. The construction of such a system is described. Wind speed can be determined to within 2-3 m/s. Figures 3; references 5: 4 Russian, 1 Western.

Vertical Structure of Upper Layer Clouds From Lidar Sounding Data

927M00709 *Moscow IZVESTIYA VUZOV SSSR. FIZIKA ATMOSFERY I OKEANA* in Russian *Vol 27 No 9, Sep 91* [manuscript received 9 May 91] *pp 974-979*

[Article by L. V. Kravets, Central Aerological Observatory; UDC 551.576].

[Abstract] This article presents generalized results of lidar measurements of the altitude and thicknesses of upper layer clouds and the distribution of the extinction coefficient over altitude in these clouds. These measurements were obtained during complex experiments performed in April-June 1986, May 1987, and May-June 1989. Empirical relations are obtained which describe the dependence of cloud thickness on temperature and the vertical profiles of the extinction coefficient. The experiments revealed a relatively uniform distribution of altitudes and cloud thicknesses. Studies of clouds with various lower boundary altitudes revealed that the maximum extinction coefficient varied from the middle of the cloud to near the upper boundary. Analysis showed that the scattering was mainly concentrated directly below the tropopause in a narrow altitude band (on average 400 m below the tropopause). Figures 3, tables 2, references 5: 4 Russian, 1 Western.

Parametrization of Filters Retrieving Spatial Spectra of Sea Surface Slopes From Optical Images

927N0065A Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Sep-Oct 91 (manuscript received 3 Sep 90) pp 51-58

[Article by A. B. Murynin, Kometa Central Scientific Research Institute, Moscow, UDC 551.46]

[Abstract] Measurements of sea surface spectra from optical images involves definite difficulties due to the nonlinearity of the transfer function relating the slopes of sea surface elements and their brightnesses. A solution was sought for this problem by the author in ISSLED. ZEMLI IZ KOSMOSA, No 6, pp 60-70, 1990 and by V. G. Bondur and the author in OPTIKA ATMOSFERY, No 4, pp 387-395, 1991. This article is essentially a continuation of these earlier two studies. The method which is developed involves measuring the two-dimensional spectrum of the field of rises of the sea surface from the signal registered in the image with allowance for nonlinearity of the slope-signal transfer function. The method involves discrimination of several fragments of the optical image, formation of the spectra of these fragments and retrieval of the spectra of the fields of projections of the slopes of sectors of the sea surface represented on the optical image fragments from the spectra of fragments of the optical images using nonlinear retrieval operators dependent on optical image formation conditions. The method makes it possible to determine the mean spectrum of rises for several sea surface sectors when using several fragments of one optical image having different signal gradient orientations or the spectrum of a sector of the sea surface from several images registered from different positions. On this basis spatial-frequency filters are found for retrieving the spectra of sea surface slopes. An analytic approximation of these filters is obtained and the dependence of the approximation parameters on image formation conditions is determined. Figures 3, references 14: 12 Russian, 2 Western.

Large-Scale Variability of Circulation and Thermal State of Atmosphere and Ocean in North Atlantic

927N0063B Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 5, Sep-Oct 91 (manuscript received 31 Jul 90, after revision 17 Oct 90) pp 23-27

[Article by A. A. Sizov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol, UDC 551.465.63.061.1:0]

[Abstract] An analysis was made of the large-scale variability of circulation and the thermal state of the atmosphere and ocean on the basis of the year-to-year variability of the Rossby index and the thermal and dynamic characteristics in individual parts of the northern subtropical circulation, with emphasis on relationships to the 22-year solar activity cycle. The 22-year cycle ending in 1986 was characterized by a higher intensity of atmospheric circulation than was the preceding 22-year cycle (1944-1964). The beginning of the current 22-year cycle (in 1990) the large-scale atmospheric circulation over the North Atlantic was characterized by the phase of the first maximum; it shows that the intensification of atmospheric circulation is not weakening. Postulating that 1990 belongs to the group of years characterized by the phase of the secular variation maximum in disturbance of atmospheric centers of action, it can be anticipated that an anomalously high atmospheric circulation will persist at least to the end of the current 22-year cycle (the end of this century, through the beginning of the next). With these considerations taken into account, it is concluded that there are two limiting regimes in the large-scale circulation of the North Atlantic. The first of these regimes is characterized by a high level of circulation in both the atmosphere and in the subtropical circulation of waters. In the current century this regime has been observed predominantly in years tending to the middle and end of the 22-year cycle. The second regime is characterized by a relatively low level of atmospheric circulation and a weakening of the transport of water masses in the northern subtropical circulation. This regime has predominated for the most part in years tending to the beginning and second half of the 22-year cycle. Figures 2, references 17: 13 Russian, 4 Western.

Distribution Laws of Atmospheric Transparency Coefficient for IR Radiation on Horizontal Paths

927N0063A Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 (manuscript received 25 Feb 91) pp 796-802

[Article by Ye. R. Mikutin, A. I. Serbin and Yu. I. Yaremenko, Leningrad Communications Electrical Engineering Institute imeni Prof. M. A. Bonch-Bruyevich, UDC 551.593.2]

[Abstract] An analysis of experimental data on atmospheric extinction of laser radiation at $\lambda = 10.6$ μm made it possible to determine the form of atmospheric transparency distribution functions for this wavelength which were then compared with similar characteristics for

wavelengths 0.55 and 1.06 μm. The extinction of radiation of a CO_2 laser in the atmosphere was measured using the IKAU-1 IR measuring system. Such a system, by means of multiple reflections, on a 100-m uniform horizontal base makes it possible to obtain a set of paths 400 to 4000 m in length. The measurement method described elsewhere in the literature was used in carrying out experiments over a three-year period during different seasons. A total of 19,062 reckoning points were obtained during a total registry time of 170 hours. Each experiment lasted from 30 minutes to six hours. Data files were obtained for three spectral emission lines of the CO_2 laser: P_{20}, P_{22}, P_{24}. It was found that there are stable correlations between the factors determining the state of the atmosphere and the extinction of radiation at $\lambda = 10.6$ μm. The distribution laws for the atmospheric transparency coefficient were found for $\lambda = 10.6$ μm for the northwestern region of the European USSR. It is shown that a truncated Weibull distribution, approximating well the empirical distribution of the atmospheric transparency coefficient in the visible and IR ranges, also is applicable for describing the atmospheric transparency coefficient in the middle-IR range, governed by the aerosol extinction of radiation. Figures 2; references 16: 13 Russian, 3 Western.

Transfer of Radiation of Optical Beam in Spatially Limited Scattering Volume

92TN0038 Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 29 Nov 89; pp 819-826

[Article by B. V. Goryachev, M. V. Kabanov and B. A. Savelyev, Siberian Physical Technical Institute imeni A. D. Kuznetsov, Tomsk Polytechnic Institute imeni S. M. Kirov, Tomsk; UDC 535.36]

[Abstract] A solution of the problem of transfer of optical radiation in a spatially bounded medium is given. Analytic expressions are derived for different experimental schemes: the radiation source and receiver are positioned on the boundaries of the scattering volume; the radiation source is located within the scattering volume and the receiver is at its boundary, or vice versa. First the intensity of multiply scattered radiation is computed with allowance for source and receiver positioning within the scattering volume and then the intensity of multiply scattered radiation is computed with allowance for the spatial dimensions of the optical beam. The research results ensured a thorough interpretation of the influence of the background of multiply scattered radiation on the brightness contrast of laser sources observed through a scattering medium. In the case of great optical depths a major role is played by the background level of multiply scattered radiation forming the scattering volume outside that illuminated directly by the optical beam. The limiting optical depth τ_{lim} at which the brightness contrast of the observed radiation disappears is dependent not only on the geometric dimensions of the optical beam and scattering properties of the medium, but also on the dimensions of the entire scattering volume. This is a new and fundamental finding with respect to the dependence of τ_{lim} on the properties of the medium and the geometry of observations. The theoretical results are in good agreement with the experimental data, demonstrating the applicability of the exponential law to description of radiation extinction in disperse media. Figures 4; references 7: 6 Russian, 1 Western.

Retrieval of Extinction Index Profile Using Data From Single-Angle Lidar Sounding of Atmosphere

92TN0010C Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 4 Feb 91; pp 850-857

[Article by V. A. Kovalev, Yu. Ye. Ryabukov and V. M. Ignatenko, Main Geophysical Observatory imeni A. I. Voyeykov]

[Abstract] Algorithms are written for retrieving from a lidar signal the profile of the extinction index for transmission coefficient in the sounding direction. The processing procedure assumes that the conditions of single scattering and a power-law relationship between scattering and extinction are satisfied. Two different algorithms for determining the extinction index profile are examined. The algorithms were finalized and checked in a large series of experiments. Specific examples of the results are given. The processing algorithms applicable in the case of restricted visibility in most cases ensure a good agreement with data from control instruments, including for slant paths, and is promising for use in retrieving transparency profiles in a wide range of meteorological situations. The good agreement between regulated data and the results of processing of lidar signals using the algorithm for a two-layer atmosphere confirms, first of all, the good prospects for its use when there is a strong burst of the backscattered signal at the end of the sounded path from the cloud layer and second, the need for preliminary identification of the meteorological situation under which this signal is received prior to signal processing. Figures 3; references 35: 13 Russian, 22 Western.

Some Problems in Linear Filtering of Images Distorted by Scattering Media

92TN0038J Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 1 Apr 91; pp 838-849

[Article by V. V. Belov, B. D. Borisov and N. V. Molchanov, Atmospheric Optics Institute, Siberian Department USSR Academy of Sciences, Tomsk; UDC 621.386.01:001]

[Abstract] An in-depth study was made of the possibility of using known methods, some already classical, for the retrieval of images distorted by scattering media. Details of image formation at the registry instrument output with allowance for the transmission of an optical signal through turbid, optically dense scattering formations are

directly examined because the influence of such a medium on image formation is similar to that from the presence of a LF filter. Emphasis is on analysis of the sources of errors arising in computer retrieval of quantized images. Proper retrieval can be compromised by such factors as inaccuracy in stipulation of the point blurring function, quantization range, instrument noise and the spatial limitations on frame formation (each of which are discussed in detail). In the example of a spatially limited object it is shown that for real digital images containing a noise component it is necessary to use a considerable degree of smoothing of the solution for compensating for the quality loss caused by noise errors in selecting the pulse transient function for the distorting medium and the spatial limitation related to image frame formation. The problems involved are examined in specific examples and special cases are considered. Figures 2; references 7: 6 Russian, 1 Western.

Method for Retrieval of Image From Its Convolution With Unknown Pulsed Response

[Text] [Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 18 Dec 90] pp 849-851

[Article by D. V. Maklakov and A. D. Ryabkin, Astrofizika Scientific Production Association, Moscow] [UDC 522.6:621.315.3.087]

[Abstract] Commonly employed image retrieval methods are based on use of a priori information on an image O(x,y) or pulsed response H(x,y) or on averaging of a large number of registered images with constant O(x,y) and randomly changing H(x,y). Studies were made of the possibility of retrieving the true image directly from the registered image. Although a number of such retrieval methods are known, they are exceedingly sensitive to noise and require a precise knowledge of the image and the pulsed response. The proposed image retrieval method is based on solution of the so-called phase problem, essentially involving retrieval of a spatially limited function from the modulus of its spatial spectrum. It is shown that by using known iteration algorithms for retrieving the spatial spectrum of a finite function it is possible to retrieve the required operational function, usually with 50-100 iterations, with the optimum relaxation coefficient falling in the range 0.4-0.6. The image itself is retrieved using 30-40 iterations. The relative rms error of the retrieved image is about 1% percent. However, this retrieval method as proposed is still inadequately immune to noise. Already with a signal-to-noise ratio 15-20 it no longer gives a satisfactory image evaluation. Therefore, theoretically the proposed method is promising but its practical use is made difficult due to the inevitable noise in image registry. Figure 1, references 7: 6 Russian, 1 Western.

Influence of Grayness of Ocean Surface on Accuracy in Determining Its Temperature From Angular IR Measurements From Space

[Text] [Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 21 May 91] pp 826-861

[Article by A. M. Ignatov and V. S. Suyetin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol] [UDC 551.46]

[Abstract] The difference of the sea surface from an ideally black radiator was investigated within the framework of an earlier proposed approach to analysis of errors in determining ocean surface temperature on the bases of statistical data on atmospheric variability (V. S. Suyetin, et al. OPTIKA ATMOSFERY, Vol 2, No 7, pp 750-757, 1989; Vol 3, No 6, pp 622-627, 1990). A more thorough investigation along these lines revealed that allowance for this factor in the radiation model is manifested in an increase in errors and appearance of a minimum on the curves representing error dependence on the sighting angle. The effectiveness of two- and three-angle measurement methods is compared. The analysis reveals the effect resulting from replacement of a single degree of blackness in the radiation model by more realistic values corresponding to a smooth ocean surface. In individual atmospheres with a low moisture content the errors in determining OST increase and their dependence on variations of atmospheric parameters is enhanced. With a realistic level of error in registering radiation 0.1 K the accuracy of the two-angle method falls in the range 0.5-0.5 K, the use of additional measurements in a third angle does not result in any significant improvement. The curves representing the accuracy in determining OST by the two-angle method on the choice of the second sighting angle have a distinct minimum in the region near 55°. Figures 5; references 6: 5 Russian, 5 Western.

Spectral-Angular Parametrization of Satellite IR Measurements of Ocean Surface Temperature

[Text] [Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 manuscript received 29 Apr 91] pp 862-867

[Article by A. V. Razanskiy, Automation and Control Processes Institute, Far Eastern Department, USSR Academy of Sciences, Vladivostok] [UDC 551.46]

[Abstract] The inadequacy of the linear theory of the multichannel method for IR measurements of ocean surface temperature (OST) through the atmosphere is demonstrated. An effort was made to rectify this situation. Satellite data for the period August-October 1990 were registered in the Philippine Sea region. The survey times were characterized by few clouds and small variability of ocean surface temperature. Ten-day OST charts issued by the Japanese Meteorological Agency and

shipboard observational data were used in the processing, which involved construction of radiation temperature histograms for each satellite revolution. Using a second-order approximation of the atmospheric transmission function in the radiation transfer equation a four-channel parametrization of IR measurements of ocean surface temperature was made using two spectral measurements at two zenith angles. In situ OST data and NOAA-10/AVHRR data in the ranges 3.7 and 10.8 μm were used in testing different two-channel reductions of this parametrization. Data for three surveys were analyzed: the first corresponded to an extremely great atmospheric water vapor content, the third was characterized by an extreme moisture deficit aloft in an extensive zone of air subsidence and the second corresponded to average conditions. Study of these and other data indicate that angular IR measurements, or at least a synoptic adaptation of the angular parameter, are necessary for precise determination of OST. References 12: 6 Russian, 6 Western.

Determining Transparency of Lower Atmospheric Layers From Extinction of Cerenkov Light of Extensive Atmospheric Showers

927N0038H Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 (manuscript received 25 Feb 91) pp 868-873

[Article by M. N. Dyakonov, S. P. Knurenko, V. A. Kolosov and I. Ye. Sleptsov, Space Physics Research and Aeronomy Institute, Siberian Department, USSR Academy of Sciences, Yakutsk; UDC 551.521.31:551.591]

[Abstract] A method is described for determining the transparency of an atmospheric near-surface layer with a thickness up to 6-7 km for a light source with the spectrum $d^2W/dld\lambda$ about $1/\lambda^3$, corresponding to the Vavilov-Cerenkov radiation (VCR) of charged particles of extensive atmospheric showers formed as a result of interaction between cosmic rays and air atoms. The observations were made in the Yakutsk extensive atmospheric showers (EAS) registry system, where VCR (Cerenkov light) has been registered since the early 1970's. This radiation is attenuated on its path to the light detector. The structure and functioning of this system, made up of 59 stations, is described. Details are given on signal registry, storage and analysis. The flux of EAS relativistic electrons causes a burst of Cerenkov light for 10^{-7} s. This light pulse can be registered against the background of night airglow using photomultipliers. This constitutes the basis for the described method for monitoring atmospheric transparency. The concept of a "calibration night" is employed. On such a night the light losses on aerosols are minimal and constitute half the losses from Rayleigh light scattering. Data were collected on relative atmospheric transparency as a function of time of day for 15-minute intervals since atmospheric transparency may vary greatly during the course of the night. The values of the mean transmission coefficient are given for an atmospheric layer in the wavelength range λ_1-λ_2 = 300-800 nm under conditions favorable for optical observations in the Yakutsk EAS registry system. Figures 4; references: 10 Russian.

Optimal Estimate of Concentration of Atmospheric Components by Lidars in Photon Counting Detection Mode

927N0038I Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 (manuscript received 30 May 91) pp 883-887

[Article by V. M. Dubyagin and N. A. Shefer, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 535.216]

[Abstract] The problem of optimum estimation of concentrations of atmospheric components is examined. The emphasis is on lidars with event-by-event measurement of the energies of laser pulses by shunting a small part of the radiated flux present in one frequency channel operating in a photon counting mode. Since the optimum estimate in the sense of a minimum of dispersion for these lidars is too complex, two suboptimal estimates of the concentrations of atmospheric components are synthesized which are suitable for elastic scattering, Raman scattering and resonance fluorescence lidars. The change from intuitive estimates, which have commonly been employed, to optimal or suboptimal estimates in many cases requires only an insignificant change in the algorithm for computer processing of lidar signals or a simple improvement in lidar apparatus. Two formulas are derived for the proposed estimates and it is shown in a specific example the advantage of one in comparison with the other and the usually employed intuitive estimation. Figures 3; references: 3 Russian.

Use of Knowledge Engineering Methods for Solving Problems in Atmospheric Correction of Remote Measurements

927N0038J Tomsk OPTIKA ATMOSFERY in Russian Vol 4 No 8, Aug 91 (manuscript received 30 Apr 91) pp 888-895

[Article by Ye. I. Pospelova, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 535.96]

[Abstract] This is a review of studies on the application of knowledge engineering methods to the processing of remote sensing data. An expert system is described which takes into account the influence of the atmosphere on the propagation of thermal radiation in the atmosphere-underlying surface system. Particular attention is given to an expert system for atmospheric correction of remote sensing data which involves determination of the vertical profiles of the extinction coefficient, transmission function, optical depth and intensity of outgoing thermal radiation. The applicability of an expert atmospheric correction system in obtaining information on the vertical profiles of temperature, pressure andconcentrations of atmospheric gases also is discussed. It is shown how the special features of the subject field exert an influence on realization of the fundamental principle of the system: the need for participation of the user in the

choice of relevant data and research methods. The directions of possible application of prototypes of the represented system for the solution of practical problems are indicated. The use of the artificial intellect method is still in its initial development stage. The concepts of "intellectual" interpretation of remote measurements are only now being formulated. The basic structures of data and knowledge bases must be worked out and optimum modes of interaction with the user must be studied. All this will be highly useful to researchers with very limited computer skills. References 18: 11 Russian, 7 Western.

Shoreline Change With Rapid Rise of World Ocean Level Due to 'Greenhouse Effect' Influence

927N0102A Moscow GEOMORFOLOGIYA in Russian No 2, Apr-Jun 92 (manuscript received 25 Sep 91) pp 3-13

[Article by P. A. Kaplin, A. V. Porotov and A. O. Selivanov, Geography Faculty, Moscow State University; Institute of Water Problems]

[Abstract] After examining prevailing concepts on the character of reformation of the coastal zone when there is a rise in sea level, the authors made a reconnaissance study of the possible consequences of a sea level rise in the 21st century for the coasts of Russia and contiguous countries on the assumption of rises by 1 m and 4 m by 2100. These rises are close to the mean and maximum estimates made by many researchers. Sketch maps were prepared showing the consequences of a rise by 1 m for the coasts of Russia and by 4 m within the limits of the Sea of Azov basin. The first of these maps was at 1:4 000 000 and the second at 1:200 000. In the article the first attempt is made at predicting the consequences of a rapid rise in the world ocean as a result of climatic warming. The prepared maps must be regarded as a first approximation. The quantitative estimate of the zone of reworking of shores was based on the approximate formulas of P. Bruun and others and data on the destruction of shores. The paleogeographic analogies method was effective. The quantitative method made it possible to discriminate risk zones (shore destruction and shoreline retreat resulting in catastrophic consequences, inflicting irreversible losses on the mapped natural and economic objects). Natural and economic risk zones can be distinguished. Future directions to be pursued in this field are suggested. Figures 2; references 42: 20 Russian, 22 Western.

Predictive Estimate of Cesium-137 Field in Black Sea Surface Waters

927N0100C Moscow OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 2 Oct 90, after revision 18 Dec 90) pp 253-256

[Article by M. M. Domanov and A. Ye. Gorbunov, Oceanology Institute imeni P. P. Shirshov, Moscow; UDC 551.465.7]

[Abstract] As a result of the fallout of radioactive aerosols after the accident at the Chernobyl nuclear power plant a specific field of radioactivity was formed in the surface layer of the Black Sea. A prediction of the transformation of this field with time makes it possible to foresee the direction of transport of radionuclides and the rate of elimination of radionuclides from the surface layer and also to detect the position of zones with an increased content of radioactive elements in sea water. It is estimated that the total quantity of cesium-137 entering the Black Sea as a result of the fallout of products from the accident is about 45 KCi. Such data and published information on the temporal transformation of the cesium-137 field in the surface layer were used in model investigations of structural changes in the cesium-137 field in the Black Sea. The used hydrophysical model was verified by a comparison of the computed fields with in situ measurement data. The mapped fields of cesium-137 distribution indicate the formation of stable zones of nonuniform content of radionuclides. The surface layer is characterized by the transport of radioactive pollutants in a westerly direction. Then the impurity, due to vertical transport, enters into the lower layers and is carried in an easterly direction. A compensating outflow is characteristic for regions lying deeper than 1000 m. Figures 4; references 10: 9 Russian, 1 Western.

Anticipated Global Anthropogenic Climatic Changes Caused by Joint Influence of Carbon Dioxide and Carbonyl Sulfide

927N0081A Moscow IZVESTIYA AKADEMII NAUK SSSR. FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 pp 227-233

[Article by A. S. Kabanov, Experimental Meteorology Institute; UDC 551.588.7]

[Abstract] The objective of this study was a determination of the joint correlated effect exerted on the global thermal regime of the atmosphere by future anthropogenic changes in the atmospheric content of carbon dioxide and stratospheric sulfuric acid aerosol. As a result of oxidating reactions transpiring in the stratosphere the gas carbonyl sulfide (CSO) is transformed into sulfuric acid vapor. The joint effect of such a singular source of acid vapor, macroturbulent diffusion processes, as well as formation of aerosol on condensation nuclei and growth of droplets, results in formation of a vertical profile of gases, CSO and H_2SO_4, and a stationary particle size distribution. Against this background a study was made of three possible scenarios of fossil fuel combustion. It is postulated that there will be a rapid temperature increase in the one- or two-decade period prior to 2150 in two of these scenarios with maximum changes in fuel combustion, that is, up to 2100-2130 there will be a considerable restraint of temperature rise by stratospheric aerosol in connection with the greenhouse effect. After attaining a maximum of combustion intensity in 2100, with its subsequent rapid dropoff and a decrease in the mass of stratospheric aerosol, the temperature will begin to rise rapidly due to the greenhouse effect caused by the accumulation of atmospheric carbon dioxide. Such a characteristic temperature behavior with its sharp increase during relatively short time intervals must be taken into account in the prediction of future changes in climate and in the planning of fuel combustion intensity. Figures 3; references 13: 10 Russian, 3 Western.

Global Warming and Its Consequences

[Abstract from Russian journal METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 7 Jul 91) pp 5-16]

[Article by M. I. Budyko, Yu. A. Izrael and A. L. Yanshin, Main Hydrological Institute, USSR State Committee for Hydrometeorology and Environmental Monitoring, UDC 551.574.551.583.7(086)]

[Abstract] Information is given on the accumulation of carbon dioxide and other gases which are intensifying the greenhouse effect in the atmosphere and which are responsible for global warming. Emphasis is on the importance of the increased carbon dioxide concentration for increasing the productivity of agricultural plants. Two rational variants for validating an optimum strategy for contending with global warming (solutions are suggested) are based on simple economic considerations; one is based on choice of an optimum strategy for economic development. The following three conclusions are drawn with respect to an effective strategy for dealing with the developing situation: First, there must be a considerable increase in the scientific level of research on all problems related to global warming. This research must relate to a far broader range of problems in comparison with the attention now being given to the situation and must be coordinated by the most competent specialists. Second, it is desirable to validate the safest and most economical ways to adapt economic activity to global warming. Third, there is now no adequate scientific validation for assessing the prevailing trends in development of global energy production, in particular for reducing the increasing consumption of carbon fuel. Figure 1; references 10: 9 Russian, 1 Western.

Programming Complex for Simulating Cases of Strong Atmospheric Pollution at Alma-Ata

[Abstract from Russian journal METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 29 Jan 91) pp 11-19]

[Article by E. A. Zakarin and V. F. Kramar, Mathematics and Mechanics Institute, Kazakh Academy of Sciences, UDC 551.564.654.001.572.(574.51)]

[Abstract] The development of a system for on-line objective prediction of atmospheric pollution (TOPAZ project) including the software employed in this system is described. The work was directed to the simulation of processes of transport and dispersal of pollutants in the atmosphere over Alma-Ata. Figure 1 is a block diagram which carries the components of the TOPAZ system, its functioning and the research program as a whole; this figure serves as a basis for the textual discussion. A mathematical model is formulated which is based on representation of the computation volume in the form of a system of boxes linked by balance relations of the advective-diffusive transport of pollutants. Within the boxes provision is made for a procedure for detailed examination of concentration fields using the formulas for Gaussian plumes. Computations were made for a period corresponding to the CO-86 experiment carried out at Alma-Ata. Comparison of the measured and computed data revealed a good agreement with respect to the dynamics of mean values and detailed fields of carbon monoxide concentration. Due to the high degree of automation and ease in adjustment the TOPAZ system can serve as a working tool for a team of experts in planning air conservation measures, in selecting sites for new industrial facilities and in reducing effluent. Figures 3; references 10: 8 Russian, 2 Western.

Heat Accumulation in North Atlantic and Its Multiyear Variability

[Abstract from Russian journal METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 7 Feb 91) pp 77-85]

[Article by R. A. Ratman and Ye. V. Balashova, USSR Hydrometeorological Scientific Research Center, UDC 551.465.4.551.515.6.551.582.2(261.1)]

[Abstract] Using WDC data, information on heat accumulation in the upper quasihomogeneous layer of the North Atlantic is analyzed. Alternating meridionally oriented regions were discovered in which the annual balance of heat accumulation is impaired (the annual sums dQ/dt are either positive or negative). In these regions compensation mechanisms are operative in the form of positive trends of heat content in those places where the annual sums $dQ/dt < 0$ and in the form of negative trends for $dQ/dt > 0$. The change in thermocline depth is controlled by this mechanism. The principal features of the seasonal and interannual variability of heat accumulation are discussed. Specific information is given on seasonal changes in heat accumulation for January, March, May, July, September and December. The January field is characterized by heat accumulation over the greater part of the ocean and its losses along the shores of the continents, in the Gulf Stream and in the Norwegian Current. In March the picture changes considerably; heat accumulation occurs in the eastern part of the ocean (especially in the Norwegian Energy-Active Zone) but also in the Sargasso Sea. However, in the central part of the ocean and in the Gulf Stream the upper quasihomogeneous layer loses heat. A generally similar picture is observed in April but with the difference that the regions of heat loss increase. In May and June the upper quasihomogeneous layer loses heat over almost the entire ocean surface and the losses attain a maximum in the annual variation. In July and August a gradual intensification of heat begins in the coastal regions. September, October and November are months where heat accumulates virtually everywhere in the upper quasihomogeneous layer, which also continues in subsequent months, attaining a maximum in December-January. But regions of heat loss already appear in December which increase still more in January. Figures 3; references 7: Russian.

Second World Conference on Climate. II. Evaluations of Global Climatic Changes and Measures for Preventing Global Changes

927N0079A Moscow IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian Vol 123 No 6, Nov-Dec 91 (manuscript received 20 Nov 90) pp 473-480

[Article by K. Ya. Kondratyev, St. Peterburg; UDC 911:551.58]

[Abstract] The results of the Second World Conference on Climate and work of the Intergovernmental Group of Experts on Climatic Changes are reviewed. High points, achievements and deficiencies are examined. The author has strong negative opinions with respect to many of the reports and theses presented at the conference. The role played by the USSR in this conference also is viewed in an unfavorable light. The work at the national level on preparations for the second conference, directed by the Main Administration for Hydrometeorology, is deemed unsatisfactory. The scientific report of the Intergovernmental Group is virtually devoid of indications that there has been Soviet research in the field of climatology. Although the USSR has a meteorological space system, the report contains no information on this. Even bibliographic references are limited to a few journal articles (there are no references to many recent Soviet monographs on this subject). The Soviet representatives in Working Group I evidently did a poor job in a number of ways. Many foreign governmental and nongovernmental agencies prepared numerous monographs, brochures, reports, displays and videofilms for the conference; the Soviet Union made none of these available. Only four speakers were from the USSR, and only one report (M. I. Budyko) constituted a purely scientific report (on climate prediction on the basis of paleoanalogues), but then, among the Soviet participants (a delegation of more than 20) there were virtually no climatology specialists. Ye. P. Borisenkov, director of the Main Geophysical Observatory, the most climate-oriented institute of the Main Administration for Hydrometeorology, was not present and there was only one person representing the Academy of Sciences. It appears that climatic research in the USSR is suffering due to the Main Administration of Hydrometeorology stressing its leading, even monopolistic role. References: 10 Russian.

Extraction of Oil and Gas With Nuclear Explosions

927N0078 Moscow PRIRODA in Russian No 11, Nov 91 pp 25-33

[Article by V. I. Musinov, All-Union Scientific Research and Design Investigation Institute for Industrial Technology, USSR Ministry of Atomic Energy and Industry]

[Text] There is no doubt that nuclear explosive devices created during the arms race should not be used for their original purpose. Still, is it worth destroying them and the potential energy they contain without trying to obtain some benefit for humanity?

The search for peaceful ways of using nuclear explosives was begun in the 60s by specialists in the USSR and US working on programs for their respective governments. In 1975 these studies were limited by international agreement, and it was decided to use only camouflaged nuclear explosions of limited strength. This limit was imposed so that the centers of camouflaged explosions were not directly linked (through fractures) with the atmosphere and hydrosphere, including water-bearing strata. Thus, under the defined geological and technical conditions, they were radiationally and seismically safe.[1]

Since the early 80s work on the use of nuclear explosions for industrial purposes was almost completely halted in the US. Negative public opinion played the main role in this decision, as well as the difficulties in financing research which did not yield a rapid economic benefit. This turn of events does not reflect the opinions of American scientists, many of whom are of the opinion that camouflaged nuclear explosions are quite promising, especially in the exploration for and use of natural deposits of hydrocarbons.[2]

In the USSR this type of research was conducted until 1987. Our experience is based on the results of more than 100 peaceful explosions. These results show that such explosions can be used to solve numerous practical problems. Recently this journal discussed how camouflaged nuclear explosions improve the state of the ecology.[3] Here we will speak of the prospects for the use of such explosions in the exploration for and extraction of natural hydrocarbons.

Explosions to Improve Well Technology

The energy balance of industrial nations is based on oil and gas. It is also known that oil and gas are nonrenewable natural resources. However, all current well technologies for the exploration for and extraction of these very important products are far from perfect. For example, they do not allow us to develop large deposits of natural hydrocarbons discovered in the lower sedimentary cover of Western Siberia (the Tyumen, Bazhenov and Achimov formations). These deposits of oil and gas are comparable in volume with the deposits which lie above them that have already been developed. The lower deposits remain virtually unused because of the debit of exploratory wells.

Current well technologies do not provide a high yield of oil even at developed locations. On average, the yield does not exceed 40-50 percent, and at the boundaries of gas and oil deposits, this figure is 10-15 percent. Well technologies also do not permit the development of crystallohydrate and bituminous deposits of natural hydrocarbons, which are numerous in our country.

Overall, these technologies permit the extraction of no more than 25 percent of discovered deposits of oil and gas. And if they are not substantially modernized, the energy crisis will become real in the near future (that is, if no alternatives are found to motor fuels based on oil).

The possibility of using camouflaged nuclear explosions to improve well technologies has been studied in the USSR and the US. Here explosions occurred mainly in oil and oil and gas deposits, where the collectors are of very durable carbonaceous rock of varied porosity and permeability. The depth of the deposit and the corresponding depth of explosions does not exceed 1.5 km, and the strength of the explosive devices is from 3 to 15 kt.

American experiments were conducted in gas deposits, where the collectors were very durable terrigenous rock with low porosity and permeability. These explosions occurred at substantially greater depths (up to 2.5 km) and the strength of the charges used was from 29 to 43 kt.

The results of all these experiments on oil and gas deposits convincingly proved that nuclear explosions improved the operation of the stratum-well system and yielded a significant increase in the debit of stimulated wells (see table). Moreover, a complex of special studies on the physical phenomena which accompanied the explosions made it possible to understand why this occurred and which consequences of the explosion might have an independent technological value.

Technological indicators of experimental industrial objects

Object of investigation	Characteristics of natural collector				Effective depth of explosion, $m/kg^{1/3}$	Number of explosions	Increase in well debit	Additional extraction of fuel** per explosion, $10^3 m^3$
	Rock composition	Porosity, %	Permeability, md	Saturating fluid				
"Butan"	limestone	15-20	4-64	oil and gas	6.5;8	5	1.4-1.5	80
"Gelix"	"	8-10	5-20	oil	10	5	1.6-1	-
"Canton"	"	10-15	20-40	Water*	7	2	1.5-1.6	120
"Neva"	limestone, dolomite	10-12	0.2-0.4	oil	5.7	6	>20	80
"Geshagg"	sandy shale, siltstone	10-12	0.1-0.2	gas	4.2	1	6-8	-
"Rullison"	"	7-9	0.2-0.4	"	6.2	1	10-15	-
"Rio-Blanko" (garland)		4-6	0.1	"	5.5;5.9;6.3	3	10-15	-

*Explosions about 70 m below the productive stratum.

**oil and gas. 1 m^3 of oil is approximately equal to 1000 m^3 of gas

Of all the physical phenomena which accompany camouflaged explosions, three have been isolated by researchers: mechanical transformation of the surrounding porous medium, stable electric polarization of nearby rock, and consolidation of the main mass (95-98 percent) of radioactive products in the solidified melt.

The region of mechanical transformation of the porous medium around the center of the camouflaged explosion is limited to an effective radius of 80-100 $m/kt^{1/3}$ or less. This is a qualitatively inhomogeneous formation which can schematically be represented by several zones, assuming a homogeneous initial medium.

The central zone (I), with a radius of 25-35 $m/kt^{1/3}$, is characterized by a developed system of radial and tangential macrofractures. Due to the abundance of intersecting fractures the rock in this zone is unstable (which leads to its collapse into the explosion cavity), the permeability of fluids is very high. All of this enables us to consider zone I as a large volume (10^4-10^5 m^3) suitable for the separation of the arriving liquids and gases and the collection of liquids and solid suspended matter.

The intermediate zone (II) is a shell of residually deformed rock 10-15 $m/kt^{1/3}$ thick. The rock here is in a stressed state contributing to the static compression of the shafts of the wells. Large pores and fractures appear in this zone. Zone II, in which the rock of the central zone is relieved of the effect of external pressure, can be considered an additional barrier in the path of fluids moving toward the center of the explosion or from it.

The external zone, zone III, has a radius of 80-100 $m/kt^{1/3}$. Here only individual microfractures are formed, that is, deformation of the rock remains almost unchanged. This zone can be seen as a rock massif adjacent to the center of the explosion. In this massif there is an insignificant increase (by about a factor of 1.5) in the conductance of fluids.

Along with mechanical transformation of the surrounding porous medium, camouflaged nuclear explosions are accompanied by a stable electric polarization of the rock. The region of anomalous electric polarization encompasses the intermediate and external zones, and frequently extends for 200-250 $m/kt^{1/3}$. The voltage of the electric field in the anomalous region is directed

toward the center of the explosion, which provides an additional increase in movement of liquids to the center of the zone broken up by the explosion (reverse displacement is prevented by electrostatic forces, especially in the intermediate zone).

The technological significance of this effect was noted for the first time during experimental industrial work at "Neva."[4] The studies conducted here showed a dependence of anomalous electric polarization on the properties of the rock collector, which makes it possible to plan the use of this consequence of the explosion. The mechanism of its effect on the mobility of stratal fluids was also established, that is, the effect of anomalous polarization on the layer of liquid absorbed by the surface of the filtration channel.

Experiments [illegible] the anomalous electric polarization is [illegible] significant only for rock collectors with [illegible] pores, and the consequences of a camouflaged [illegible] explosion will always appear in zone II, where, due to compression, the rock acquires the properties of semiconductors. This facilitates the movement of liquid to the center of the explosion. It is for this reason that [illegible] create liquid in the central zone. This [illegible] confirms the dependence of the rate of filtration [illegible] on the constant component of the vectors of electric voltage [illegible] pressure of liquid observed in experiments.[illegible]

These [illegible] permit us to state that the main [illegible] of the products in a camouflaged nuclear [illegible] are significant. But how can we [illegible] changing the parameters of the stratum [illegible] control the process?

Specific Technologies

The technological significance of the consequences of a camouflaged nuclear explosion depends not only on the features of the medium transformation, bu also on the geological structure of the deposit of natural hydrocarbons and the means of developing them. About 80 percent of the deposits of oil and gas are stratal deposits, for [illegible] such a large area to thickness ratio S/h is characteristic (FS/81)[5] on the order of 10^3-10^4). Real mechanical transformation of the rock collectors by a nuclear explosion cannot affect a layer noticeably exceeding the thickness of the deposit itself, because one must preserve the cover of the deposit. Thus, for most deposits explosions should be limited in strength, and should be seen as a means of affecting not the entire deposit, but only the part adjacent to the bottom hole of the well. By the way, American specialists also concluded that the area of the region subjected to the mechanical effect of the explosion does not exceed a fraction of a percent of the area of the deposit.

Experience has shown that camouflaged nuclear explosions are most effective in industrial development (exploration for and development of) deposits of oil and gas concentrated in low-permeability rock collectors with a complex structure. These deposits have remained, in essence, unused.

Experiments on such deposits were conducted at three American sites ("Giesbaggi", "Rullison", and "Rio-Blanko") and one domestic ("Neva") site. This made it possible to determine the structural principles involved and use two technologies, one of which was to estimate the filtration parameters of the productive stratum, and the other was to intensify the influx of stratal fluids.

As work at "Neva" showed, in the exploration of deposits of oil and gas in low-permeability collectors with a complex structure, one can estimate the filtration parameters of the productive stratum without releasing the stratal fluids to the surface (this estimate is one of the main tasks of exploratory work).

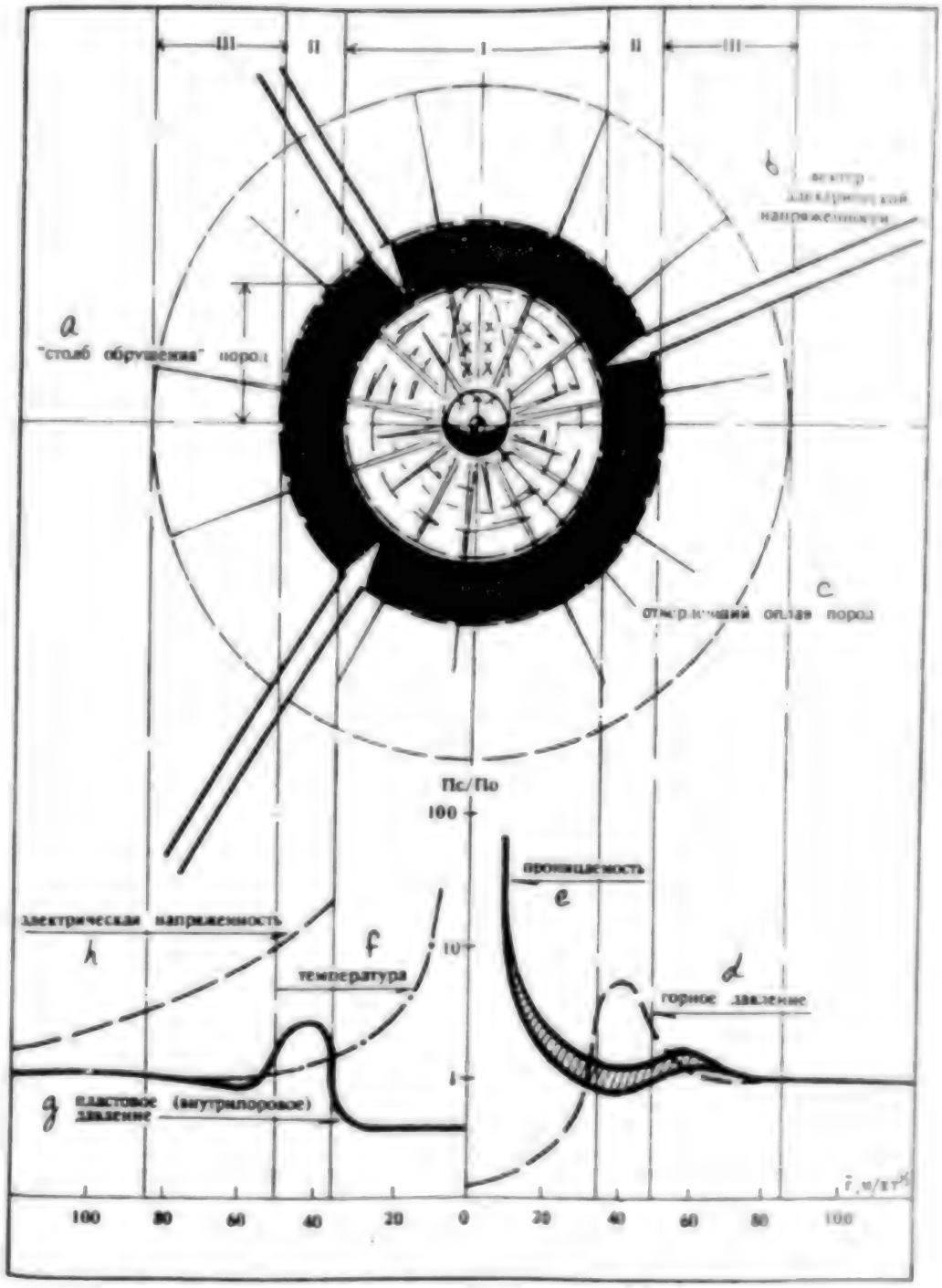
A camouflaged nuclear explosion is necessary in this technology to create a cavity of a specific size in the stratum with a decreased gas pressure. Data from remote measurements of pressure and temperature at the bottom hole of the well stimulated by the explosion were used to construct a curve which describes the restoration of pressure (pressure and temperature changed uniformly due to the effect of the influx of stratal fluids into zone I); then the desired parameters were found.

In applying this method in practice we were convinced that our estimates of the filtration parameters were close to those obtained in the usual way, in gas dynamics studies of working wells. And although this technology is rather expensive, which has already been discussed, it can be recommended for exploration work in poorly accessible regions and in complex geological conditions.

In low-permeability, fine-pored collectors where deposits are already being developed one can use this technology to increase the influx of fluids. In this case a camouflaged nuclear explosion provides a more complete opening of the deposit and increases the mobility of liquids. In-situ experiments at the listed sites have shown that one can achieve a large (more than a factor of 15) increase in the well debit.

In developing oil and gas deposits, the quality of the opening of the deposit is estimated by the effective radius of the well, that is, the distance from its axis at which the conditions of fluid movement change from a region of high (stratal) resistances to movement to a region of low resistances (in movement along tubes and macrofractures). For any well the boundary of the change in the movement of fluids depends on the condition of the zone surrounding the bottom hole, as well as on how drilling is done, on the properties of the rock composition, etc. The effective radius can be larger or smaller than the radius of the well shaft.

Due to the plane-radial movement to the bottom hole of the well, which is characteristic for stratal fluids, the well's debit is defined by the logarithm of the ratio of the feed contour to the effective radius of the well, log



Above: schematic of physical and mechanical transformation of homogeneous porous rock affected by a camouflaged nuclear explosion. Three zones are isolated (central I, intermediate II, and external III) which differ in the degree of rock transformation, and which are used to achieve various technological ends. The arrows show the vectors of electric voltage in the region of anomalous electric polarization of the rock generated in the explosion. Below: graph reflecting the change in the basic properties of a porous medium (x-axis, effective radius, m/kt$^{1/3}$; y-axis, ratio of the "stimulated" parameter to the initial parameter)

Key: a. "collapse columns" of rock. b. vector of electric voltage. c. undisturbed rock mass. d. [illegible] permeability. f. temperature. g. strata[l] pressure (intraporous). h. electric voltage

($R_k/R_{eff} + 1$). This means that an increase in the effective radius by, for example, a factor of 100 leads to an increase in the debit by a factor of two in all.

The effective radius of the well stimulated by the explosion is mainly defined by the size of zone I, where the resistance to the movement of fluids is low. Since the strength of the camouflaged nuclear explosion does not usually exceed 20 kt, the size of this zone and the effective radius of the well is 100-150 m.

It would seem that larger effective radii would be achieved. However, it is frequently inexpedient to increase the debit of a well solely by mechanical transformation of the porous medium through a nuclear explosion. It is worth doing this only in certain types of rock. In these same cases, when the standard methods of developing the well would increase the effective radius only to the size of the shaft (on the order of 0.1 m) and the mechanical action of the explosion provides an increase in the debit of no more than a factor of three to four, the technology becomes unprofitable. The cost of one well stimulated by a camouflaged nuclear explosion is close to the cost of three typical deep wells.

The mobility of liquids can only be increased in the stratum beyond the zone of fracture formation by electrophysical action on the productive layer, and this is achieved only in a fine-pored collector. Due to the features of the structure and saturation of the porous volume in the oil and gas deposit at the "Neva" site, the anomalous polarization of the rock due to nuclear explosions became technologically significant. This provided an additional increase in the debit of wells stimulated by explosions. At American sites where the natural fine-pored collector was primarily saturated with gas, the effect of anomalous electric polarization of the rock was not as significant: the increase in the debit did not exceed a factor of 10-15 (while at "Neva" it was an increase of more than a factor of 20).

Another promising way of using camouflaged nuclear explosions is improvement of the technologies of oil extraction. One of these technologies for increasing the yield of oil is associated with the development of massive deposits in an artificial "gas cap" mode. In this case an explosion is needed to create the pre-condition for gas cap formation and for a normal work mode. This is achieved due to the separation properties of the region of artificial fracturing. To develop this type of deposit into a gas cap, gas is pumped in and oil is expelled. The yield of oil is close to 60 percent, which is about two times higher than in the usual development of such deposits.

As already noted, the yield of oil from the edges of gas and oil deposits is especially low. To increase it, a special technology was developed using nuclear explosions. In this technology oil is recovered in small pressure depressions which are due to the structural properties of the central explosion zone. This oil recovery prevents the formation of breached cones of more mobile fluids (gas and water) to the bottom hole of the well. This stabilizes the spatial position of the edge and makes it possible to develop it as a typical oil deposit, attaining a yield close to 40 percent (usually 10-15 percent) and providing a total increase in the extraction of oil by more than a factor of two.

Finally, there is another possible application of nuclear explosions. It is associated with the extraction of gas from crystallohydrate deposits, where the gas is in an immobile state in the form of a solid compound with water. The gas can be removed from the crystallohydrate by decreasing pressure or increasing temperature, but to do this one must create a large evaporation surface and insure the separation of the released water and gas within the stratum. An explosion could meet both of these conditions due to the large surface of fractures it forms and by the separation and collection properties of the central zone of the explosion.

In conclusion we must add that the technologies listed here do not exhaust all the possibilities of using camouflaged nuclear explosions in the exploration for and extraction of hydrocarbons. The experience accumulated in experiments makes it possible to expand this list. But even without this it is clear that the technological possibilities of this type of explosion are extremely broad.

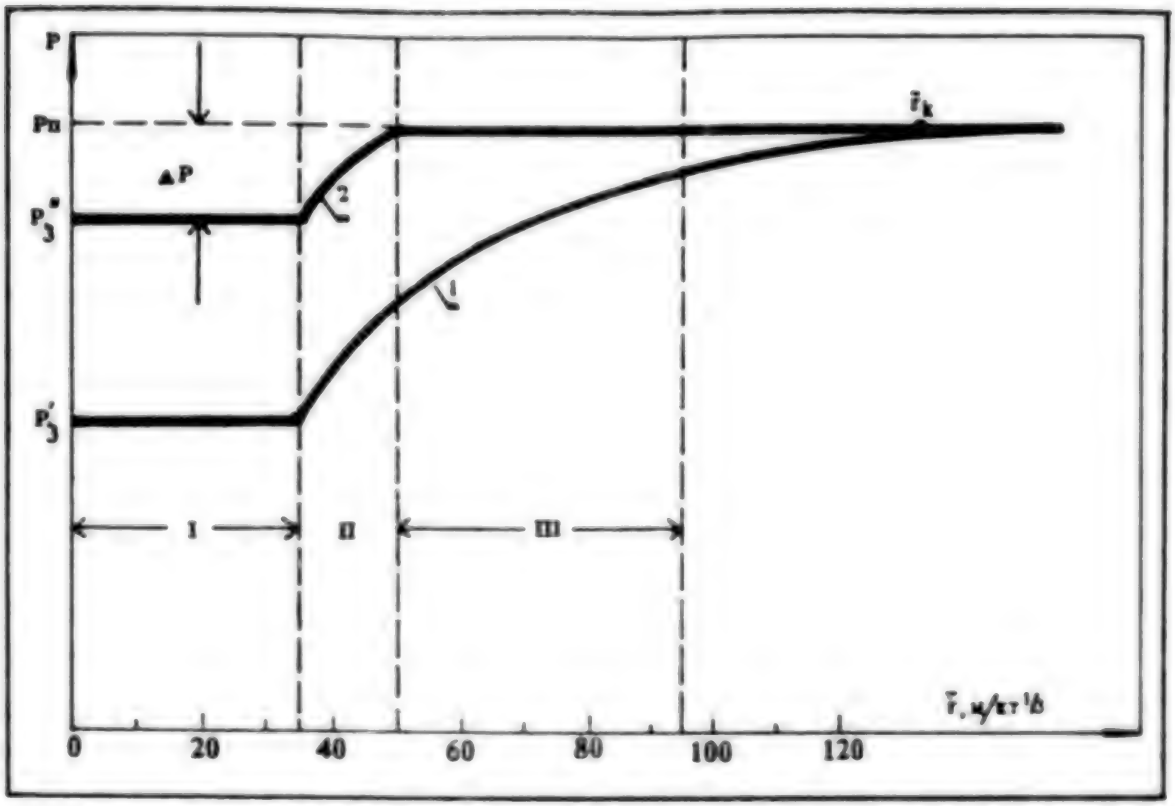
And before we give a final estimate of the prospects for the use of this type of explosion, it is necessary to answer two principal questions: how economically expedient is the use of these explosions, and are they ecologically acceptable?

Economic and Ecological Aspects of the Problem

Usually the economic expediency of new developments is judged on the basis of direct calculations using existing methods of determining economic effectiveness. However, in this case we must proceed from extremely uncertain costs for special nuclear products and the changing prices of petroleum products, which are the basic reasons to modernize well technologies with camouflaged nuclear explosions.

According to American data[3] the cost of special nuclear products is 350,000-700,000 dollars, which clearly is close to their true cost. The price of one ton of oil on the international market varies (with a tendency to increase) from 200 to 400 dollars. Given these initial data, direct calculation of the economic effectiveness of new technologies will be very inexact. Consequently, it makes more sense for us to evaluate the economic expediency of using camouflaged nuclear explosions by comparing energy indicators: the energy expended (in the explosion) and the energy obtained (due to the additional fuel recovered).

In in-situ experiments testing the use of wells stimulated by an explosion, in one explosion on average approximately an additional 100,000 tons of conventional fuel[4] was obtained. This is not the limit of the initial special technologies: this result was obtained in the intermediate stage of deposit development. However, even this result is sufficiently convincing: it means that at these sites more than a ten-fold compensation in energy costs has



Distribution of pressure P in the stratum-well system.

Key: 1. in the recovery of oil or gas from the well; 2. in the shutdown of a well and restoration of pressure in the stratum (r_k is the radius of the feed contour, r is the effective radius; I, II, and III are the internal, intermediate, and external zones in rock transformed by the explosion). The pressure at the bottom hole P_3'' and P_3' in a well stimulated by an explosion is always less than the stratal pressure $P_п$. The remaining drop in pressure ΔP is due to the properties of the intermediate zone, which forms a "barrier" resistance in the path of the stratal fluids. As a result of this pressure distribution, the pressurized movement of fluids from the central zone into the stratum is impossible until the barrier resistance is broken

been obtained. This makes it possible to positively evaluate the economic expediency of new technologies even monetarily.

In typical estimates of the economic efficiency of new developments one also considers the standard period needed for capital expenditures to pay for themselves (usually five to eight years). Assuming the minimum period and assuming that the cost of one stimulated well (considering expenditures for equipment and use) does not exceed 3-4 million dollars, and that it would operate 300 days a year, we estimate the necessary debit for a minimum value of the additional recovered fuel. Simple calculations show that the additional debit is 12 conventional fuel tons per day.

Thus, the following requirements can be imposed on the criterion of economic expediency of introduced technologies: during the working time of the new technology no less than 100,000 additional tons of conventional fuel should be recovered per explosion, and the established increase in the debit of the stimulated well should be no less than 12 tons of conventional fuel per day. As in-situ experiments show, these requirements can be fully achieved.

Now, we consider the ecological acceptability of camouflaged nuclear explosions, which is defined primarily by the possibility of overcoming the seismic and radiation consequences of an explosion. The experience of using these explosions in the conditions present in oil and gas deposits shows that the strength of these explosions should not exceed 20 kt, and the depth of the charge should be from 1 to 4 km (it is at these depths that the main deposits of natural hydrocarbons are concentrated). This makes it possible to insure the seismic safety of explosions by selecting strength depending on the depth and geographical position of the deposit.

Radiation safety can also be achieved. In a recent publication in this journal mentioned earlier, there was a detailed discussion of how to insure radiation safety in camouflaged nuclear explosions and hoe to develop the wells stimulated by them. Only one important question remains: how radiation safety is achieved in technologies

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providing for the extraction of oil and gas directly outside the zones transformed by the explosion.

In order to answer this we return to the beginning of the article, where we describe the properties of the medium transformed by the explosion. Especially important are the properties of the central zone in which all radioactive products of the explosion are concentrated, as well as the properties of the intermediate zone, in which a barrier resistance is created to the path of the movement of fluids.

The features of the central zone make it possible to separate fluids which flow in during the extraction of oil and gas, to extract components separately, to collect the stratal water which enters this zone, which after contact with radioactive products becomes the main source of danger. For example, study of the distribution of pressure in the stratum stimulated with a 30-kt explosion at the "Nevada" site showed that between the products of explosion, and the central zone of the explosion-induced cavity, it is retained for a long time (years). This difference of 5–10 atm at "Nevada" is explained by the viscosity of the intermediate zone.

By correctly using the properties of the medium transformed by the explosion, one can isolate radioactive wastes in the extraction of natural hydrocarbons. But this is possible only before the central zone is filled with accompanying stratal water. After the first extraction of useful products from the zone ceases, and the zone becomes a reliable vault for the contaminated water, which, left to itself, will cause complete destruction of the barrier resistance created by the explosion.

Thus, in order to ensure the radiation safety of the proposed technologies, one must meet two requirements: first, the cavity of the explosion should be in the productive stratum itself; second, in the extraction of oil and gas, the stratal water should not leave the central zone, and especially should not be extracted to the Earth's surface.

In-situ experiments have shown that at all sites where these requirements have been met, radiation safety of the extraction of oil and gas from the wells stimulated by an explosion was ensured. This makes it possible to speak of the principal acceptability of technologies based on the use of camouflaged nuclear explosions.

Thus, the problem of employing well technologies for the extraction of oil and gas with camouflaged nuclear explosions is completely solved. The prospects of this method are confirmed by the results of experimental industrial work at domestic and foreign sites. If our energy problems are to be solved in the future primarily by oil and gas, this research deserves development. Moreover, these peaceful explosions may be seen as an alternate means of destroying nuclear weapons.

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Definition of the Parameters of Stack Plumes Using Backscatter of Optical Radiation

[illegible]

[Article by V. A. Banakh and I. N. Smalikho, Institute of Atmospheric Optics, Siberian Department USSR Academy of Sciences, Tomsk] [illegible]

[Abstract] The backscatter of a continuous beam of optical radiation is theoretically analyzed for the case of sensing of stack plumes. It is shown that it is possible to determine the concentration of particles in stack plumes and the amount of emission of liquid droplets of pollutants from measurements of the distribution of the intensity of background light on the focal plane of the telescope. First, common equations are derived, independent of particle size and radiation wavelength. In this calculation, these factors play an important role. Particle concentration is calculated for large particles. The Fraunhofer model could here cannot be used, when there are strong winds and intense mixing because of large variations in particle concentration. However, a case with deterministic circulations, simulating complex motion of particles passing through a plume, can be treated by the accurate radiation equations, which encompass the entire contour of the smoke plume. Figures 1, bibliography 8 titles.]

Seasonal Characteristics of Distant Transport of Pollutants Toward Central European USSR

927N0054A Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 10, Oct 91 (manuscript received 25 Dec 90) pp 69-74

[Article by A. P. Katsyka, L. G. Bogatova, L. P. Mironova and R. A. Smirnova, Kaloma Pedagogic Institute; UDC 504.054:551.511.3:551.509.33(470.3)]

[Abstract] The directions of arrival of pollutants and the frequency of recurrence of individual directions of such transport were determined for the central European USSR at the single point Obninsk (this point is representative for the entire central European USSR) during 1983-1984. The directions of distant transport of pollutants can be roughly determined by evaluating sets of reverse trajectories of arrival of air masses constructed from high-level pressure pattern charts (AT_{925} and AT_{850}). The accuracy in constructing trajectories decreases with an increase in the duration of the period. An error in position and length of the trajectory results in an error in estimating the location of possible local sources of pollution and for distant transport the possibility of determining such sources is entirely precluded. The study of the directions of transport makes it possible to determine from which sources the greatest quantity of pollutants is transported and for which the concentration of pollutants is maximal. The distant transport method is fraught with many errors and therefore detection of the predominant direction of transport requires a large volume of statistics, prolonged observation periods and allowance for types of weather (circulation), on which the wind regime in the region is dependent. The directions from which pollutants are transported must be determined by seasons since the seasons differ with respect to circulation characteristics and accordingly, predominant transport directions. The seasonal changes in trajectory directions may be the most decisive factor in determining pollution concentrations. The study must be made at several levels. In constructing pollution transport trajectories it is preferable to use data on the actual wind rather than on the geostrophic wind because the actual wind more fully reflects the influence of terrain features, the closeness of shores and the presence of forests. Figures 3; references 11: 10 Russian, 1 Western.

Influence of Urbanization Process on Global Warming Estimates

927N0047A Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 9, Sep 91 (manuscript received 27 Sep 90) pp 5-11

[Article by P. Ya. Groysman and V. V. Koknayeva, State Hydrological Institute; UDC 551.583:551.588.7]

[Abstract] Estimates of the spatially averaged mean annual air temperature registered in the standard network of the State Hydrological Institute and in a specially selected network for four major continental regions (United States, Western USSR, Eastern China, Eastern Australia) were compared. The study was based on 301 northern hemisphere stations, 40 percent of them located in populated places with less than 10 000 persons; in the southern hemisphere data were used for 275 stations, 60 percent of them located in populated places with fewer than 10 000 persons. This analysis of the contribution of urbanization to changes in mean air temperature over a considerable part of the most densely populated regions of the extratropical part of the northern hemisphere and one region of the southern hemisphere indicated that in three of the four regions this contribution is negligible and in the fourth does not exceed 20 percent of the observed changes in mean air temperature of the region. It is improbable that the tropical and Western European regions not covered in the analysis could significantly increase the estimate of the contribution of urbanization to the global warming process. Taking into account that over the oceans there may be no such contribution to the estimates of air temperature change, the total influence of urbanization on the global temperature trend does not exceed 0.02-0.05°C/100 years, which is less than 10 percent of the absolute value of this trend. Figure 1; references 10: 3 Russian, 7 Western.

Reaction of Glaciation to Impending Climatic Changes

927N0055A Moscow IZVESTIYA AKADEMII NAUK SSSR. SERIYA GEOGRAFICHESKAYA in Russian No 5, Sep-Oct 91 (manuscript received 14 May 91) pp 35-45

[Article by V. M. Kotlyakov, M. G. Grosvald, M. B. Dyurgerov and V. L. Mazo, Geography Institute, USSR Academy of Sciences; UDC 911.2:551.324:551.583]

[Abstract] The possible changes in glaciation associated with the greenhouse warming of climate are examined. The primary objective is to show that in estimates of the impending rise in ocean level it is necessary to avoid errors related to underestimation of the role which will be played by losses in mass of ice due to the breaking away of icebergs and an illegitimate assumption of a linearity of the correlation between temperature increase and decrease in glaciation (most modern predictions of ocean level changes are based precisely on such an unwarranted assumption). The mechanism of instability of sea glacial formations which may result in their catastrophic decay and a rise in ocean level by 5-7 m in a very short time is examined. (The rate of rising of ocean level was found to be higher than that found by such authors as G. Robin; the discrepancy is attributed to erroneous assumptions by that author.) Detailed computations are given for an extremal regime of mountain glaciation in the temperate and subtropical latitudes with a distinctly negative (as much as -3, -5 m/year) balance of mass, resulting in the rapid disappearance of glaciers. The discussed changes will for the most part have clearly negative geoecological consequences. For example, the runoff volume of mountain rivers will be greatly reduced, resulting in negative consequences for agricultural production. Figures 6; references 27: 13 Russian, 14 Western.

Possible Consequences of Global Climatic Changes for Soils and Their Water Regime

927N0055B Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian No 5, Sep-Oct 91 (manuscript received 31 Oct 90) pp 46-55

[Article by N. A. Karavayeva and A. F. Mandych, Geography Institute, USSR Academy of Sciences; UDC 911.2:583:551]

[Abstract] Changes in the hydrothermal regime of soils and some of their principal properties with the replacement of natural landscapes by agricultural landscapes were analyzed for the Russian Plain with attention given to increased contrast of the hydrothermal regime, sums of active temperatures and humification. The M. I. Budyko scenario of possible climatic changes was used as a basis for this examination. Qualitative conclusions are drawn concerning possible transformation of such soils as a result of the anticipated climatic changes. Under stationary climatic conditions, in the boreal and subboreal regions, from the tundra to the meadow steppe, the differences between agricultural and natural soils are as follows: in the first there is even now an increase in the contrast of the water and heat regimes, an increase in the sums of active temperatures above 10° and displacement of the moisture balance in the direction of humification for most soils. The following changes in soil formation are observed in cultivated soils in comparison with natural soils: in the soils of the tundra and northern part of the taiga zone there is an increase in the stagnation of moisture, gleyification and a trend to swampification; in the soils of the southern part of the taiga zone there is an increase in eluvial processes, acidification and dehumification, but in meadow steppe soils there is dehumification. For all these soils there is a general trend to worsening of physical properties. These changes in the hydrological regime and properties of worked soils under stationary climatic conditions in general have the same tendency as the anticipated global climatic changes. But the difference between natural and cultivated soils will be different with global climatic changes. The cultivated soils will be transformed more rapidly than natural soils, which will have an inherent inertia. Under climatic change conditions not all natural and cultivated soils will react the same; different genetic, agricultural and geologic factors also will play a role. Figures 8; references 17: 15 Russian, 2 Western.

Sequence of Environmental Protection and Technological Measures for Lessening Polluting Loads on Urban Landscapes

927N0055C Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian No 5, Sep-Oct 91 (manuscript received 9 Nov 88) pp 74-79

[Article by V. M. Khvat and V. M. Moskovkin, All-Union Water Conservation Scientific Research Institute, USSR Academy of Sciences; UDC 628.39]

[Abstract] Measures are proposed for lessening the anthropogenic impact associated with continuing urbanization and reducing the intensity of accumulation of pollutants, especially solid particles, in urbanized landscapes. Expressions are derived for making quantitative estimates of the impact arising from different sources of contamination. Specific proposals are made for reducing the entry of pollutants into the environment. Recommendations are given on a differential approach to reduction of anthropogenic loads on the environment. The first group of measures includes those for preventing soil erosion from lawns and similar surfaces and regulation of runoff from them. The second group includes technological measures for upgrading the resistance of road surfaces to degradation. With an increase in bitumen content from 5 to 7 percent the wear is reduced by 80 percent; with the use of igneous rocks instead of sedimentary rocks wear is reduced by 60 percent; with an increase in gravel content from 50 to 70 percent wear is reduced by 50-60 percent. The third group includes technological and organizational measures directed to reducing effluent into the atmosphere from both industry and vehicles. The fourth group includes measures for reducing wear on tires. Procedures are suggested for ranking loads on the basis of their intensity and territories with respect to the degree of their pollution. Figure 1; references 8: 7 Russian, 1 Western.

Monitoring Climatic Changes in World Ocean

927N0056A Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 27 No 10, Oct 91 (manuscript received 21 Dec 90) pp 1043-1053

[Article by S. K. Gulev, S. S. Lappo and V. P. Tereshchenkov, State Oceanographic Institute; UDC 551.465:551.582]

[Abstract] The possibilities of analysis of short-period climatic variations by means of monitoring of energy-active zones within the framework of the "Razrezy" program are examined. It is shown that the energy-active zones are characterized by extremal quantities of heat flows at the ocean-atmosphere interface and their maximum variability. The effectiveness of the energy-active zones for detecting climatically significant changes in the ocean is demonstrated. Data are now available making it possible to formulate a strategy for monitoring climatic changes in the North Atlantic. In the tropical latitudes the principal mechanism of interannual and seasonal variability of meridional transport is the drift component. With this taken into account, in the tropics monitoring should stress observation of the wind field with a high resolution and heat content of the entire Tropical Atlantic. In the middle latitudes the meridional transport of heat for the most part is by a system of boundary currents (in virtually all months northward transport is determined by the Gulf Stream) and monitoring should therefore be concentrated there. In the high latitudes ofthe Northern Atlantic it is necessary to introduce constant monitoring of the regon of possible formation of convective outbreaks for the purpose of determining the influence of deep convection on the heat content of the North European Basin. The principal areas for such monitoring should be the Norwegian and Greenland Seas. Figures 5; references 39: 27 Russian, 12 Western.

Atmospheric Fallout of Metals at North Pole in Comparison With Background Regions of Northwestern Europe

927N0074A Moscow IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian Vol 123 No 4, Jul-Aug 91 (manuscript received 19 Sep 90) pp 316-322

[Article by V. N. Adamenko, K. Ya. Kondratyev and S. A. Sinyakov, Leningrad; Petropavlovsk-Kamchatskiy; UDC 910.551.5+581.5]

[Abstract] The fallout of dust and a number of metals, most of which are heavy metals or trace elements, was investigated in the Arctic and in water bodies of Northwestern Europe. Three hundred samples were analyzed, including 18 from the arctic station SP-28. It was found that the dry and wet fallout of heavy metals from the atmosphere differs by three orders of magnitude, determining the global, regional and local backgrounds. In the central regions of the Arctic and in the industrial and background regions of Northwestern Europe it is possible to identify identical groups of metals arriving from the atmosphere which differ in intensity by 1-2 orders of magnitude. The winter receipts of heavy metals in the Central Arctic are considerably greater than the summer receipts. The spatial changes in the fallout of heavy metals conform to an exponential law of attenuation in the directions of predominant transport from the principal areas of origin. There is a correlation, significant at the 95-99 percent level, between the quantity of dust and each heavy metal, making it possible to write regression equations. Applying these equations, by using the quantity of dust it is possible to estimate the content of each of the identified heavy metals. There is basis for assuming that the determination of the concentration of heavy metals in the snow cover is possible. The present-day level of fallout of heavy metals in the northwest is approximately 1-2 orders of magnitude greater than that which it was 100-150 years ago and it is an order of magnitude less than is characteristic for the Central Arctic. It is important to track atmospheric transport of heavy metals because for several very large internal water bodies the receipt of a number of heavy metals from the atmosphere is comparable to or exceeds the receipt with river runoff by a factor of 3-4. References 9: 2 Russian, 7 Western.

Influence of Solar System Gravity Field Variability on Earth's Climate

927N0074B Moscow IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian Vol 123 No 4, Jul-Aug 91 (manuscript received 5 Nov 89) pp 328-339

[Article by V. D. Kovalenko, L. D. Kizim and A. M. Pashestyuk (deceased), Dnepropetrovsk; Moscow; UDC 521+551.590.23+551.509.3]

[Abstract] A study was made to predict the general nature of climate at the end of the 20th century and during the 21st century and also to clarify the reasons for and the nature of climatic changes during past centuries and millenia. This required a systemic analysis of the motion of solar system celestial bodies, construction of a planetary climatic model and study of secular climatic changes. The nature of a whole group of geospheric processes (1-, 20-, 200- and 2000-year cycles) is explained. The concepts developed in the article indicate that the process of global cooling during the last 200-year cycle, beginning with the second half of the 20th century, will continue to the 2030's. The entire 21st century will be relatively "cold." With an increase in the cooling process there will be an increase in the temperature drop between the polar and equatorial zones. This will result in a change in global atmospheric circulation, including advection and adiabatic processes, and an increase in its instability. The region of unstable phenomena will be displaced into the middle and subtropical latitudes, as has been observed during recent years. The heat supply in growing seasons for surface plants in the northern hemisphere and the duration of these seasons will decrease. In the course of the cooling there will be a rise in the ground water level, runoff of rivers and level of inland undrained water bodies. There will be an increase in the ice content of polar and near-polar seas and oceans. The advance of continental glaciers beginning in the 1960's will continue up to the end of the 21st century. The decrease in the level of the world ocean beginning in the 1960's will continue to the end of the 2020's, after which its rise will begin and by the end of the 21st century will attain the mean long-term level. The possibility is appearing for a scientifically validated prediction of the change of these and other geosphere parameters for years, decades and centuries in advance. Figures 4; references: 17 Russian.

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